110238

APPENDIX 11
FORM 16R
LINER SYSTEMS - PHASE II

ER-WM-393:5/92

Date Prepared/Revised

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF WASTE MANAGEMENT

I. D. Number

FORM 16R
LINER SYSTEM - PHASE II

General References: 288.412, 288.431, 288.531, 289.412, 289.431, 289.531

A. Liner System is for:

- ☒ Residual Waste Landfill
  - ☒ Class I
  - ☐ Class II
  - ☐ Class III
- ☐ Residual Waste Disposal Impoundment
  - ☐ Class I
  - ☐ Class II

B. Location:

County: LUZERNE COUNTY Municipality: FOSTER TOWNSHIP

Total Acreage of Site: 4 ACRES Acreage of Disposal Area: 3 ACRES

C. Liner System Components are:

		Area (ft^2)	Is Equivalency Review Being Requested (Y/N)
☐	1. Subbase.		
☐	2. Secondary Liner.		
☐	3. Leachate Detection Zone.		
☐	4. Primary Liner.		
☐	5. Protective Cover.	SEE NOTE (1) AT PAGE 12.	
☐	6. Leachate Collection System (within Protective Cover).		
☐	7. CAP		
☐	8. Natural Attenuation		
☐	9. Composite Liner Primary or Secondary (circle one)		

D. Supporting Data:

The following information must be submitted along with this form. For information not appended to this form, indicate below where in the specifications or drawings the required information is located.

	(Drawing)	(Specification)
1. Design of Liner System. (Refer to Part II.)		
2. Liner Installation Plan. (Refer to Part III.)		
3. Compatibility of Liner to Leachate. (Refer to Part IV)	SEE NOTE (1) ON PAGE 12	
4. Physical, Chemical, Mechanical, and Thermal Properties of Liners. (Refer to Part V)		
5. Quality Assurance Plan for Construction and Installation of Liners. (Refer to Part VI)		
6. Quality Control Plan for construction and installation of liners		
7. Slope Stability Analysis		

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art II. Design of Liner System. SEE NOTE (1) ON PAGE 12.

A. Project Specifications	Subbase	Secondary Liner	Leachate Detection Zone	Primary Liner	Leachate Collection Zone	Protective Cover	CAP
Thickness (inches or mils)							
Maximum Particle Size (inches)							
Standard Proctor Density (percent) FIELD							
LAB							
Bearing Capacity (minimum) (lb/ft^2)							
Total Applied Load (lb/ft^2)							
Permeability (cm/s) FIELD							
LAB							
Slope (percent) MINIMUM							
MAXIMUM							

ieosynthetics: Where synthetic liners, geonets, geotextiles, or other geosynthetic materials are to be used, provide information as to the manufacturer, trade name, type, specifications, and composition of each product.

on-Synthetic Liners: Where clay or other soils will be used as the liner, provide information on the Atterberg Limits, soil density, moisture relationship moisture content, and sieve analysis to be maintained at the time of installation.

rainage system: Where piping is installed as part of the leachate detection, Leachate collection or gas disposal system submit plans and profile drawings of each level, cell or zone which clearly illustrates the: slope, spacing, diameter and schedule of all piping to be installed.

. **Design Basis**

or each major element of the liner system outlined above, provide the following information which supports the basis for ne design. Include copies of the results of all tests conducted at the site, assumptions, and calculations used in the design. he stability of the landfill site and design is to be determined at critical sections. This is to include any below grade xcavations/embankments or berms that may be critical. Consideration must be given to long and short term stresses, quipment loadings, filling sequence, and the possibility of earth quakes. Where geosynthetics are used, a veneer stability nalysis should be performed on the interfaces of the material and the soil or aggregates. A puncture analysis is to be ıcluded where a geosynthetic is used to protect a geomembrane. Following information is to be attached to this form and eferenced to the appropriate section.

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1. Subbase:

   i. Submit detailed information on how the subbase was sized and located, including the minimum and maximum depths to seasonal high water table and regional groundwater table. Be sure all elevations are tied to projects grid system and benchmarks. Explain this bases for the subbase size and materials selected.

   SEE SECTIONS 3.1.13 AND 3.1.16

   ii. Describe how the subbase will bear the weight of the liners, leachate detection and collection systems, wastes, cover material, and operations equipment without causing or allowing any failure of the liner system. Explain what evaluations were conducted at the site and of the subgrade materials to ensure adequacy for the projected loads. *

   iii. Discuss the potential for subsidence and the liner systems ability to allow for settlement.

2. Secondary Liner:

   i. Describe the physical, chemical, and thermal properties taken into consideration in selecting the secondary liner.

   ← SEE SECTION 3.1.13 AND APPENDIX II D.

   ii. Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or it leachate. *

3. Leachate Detection Zone:

   i. Describe the physical, chemical, and thermal properties taken into consideration in selecting materials.

   SEE SECTION 3.1.13

   ii. Submit and discuss the results of any testing conducted on the detection zone materials which ensures they will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or its leachate. *

   iii. Describe the methods for cleaning and maintaining pipes, including methods for testing installed pipes for leakage. *

   iv. Describe how the leachate detection zone will support the primary liner without causing punctures in the event of subsidence. *

4. Primary Liner:

   i. Describe the physical, chemical, and thermal properties taken into consideration in selecting the secondary liner.

   SEE SECTION 3.1.13 AND APPENDIX II E.

   ii. Submit and discuss the results of any testing conducted on the liner material which ensures it will not be adversely affected, both chemically and structurally, by the chemical characteristics of the waste or its leachate. *

5. Protective Cover:

   i. Provide a detailed description of the physical and structural aspects of the protective cover. Include information on the size, types, dimensions and depths of all materials used, slopes, calculations on anticipated stresses and loads from wastes and operating equipment. Describe how the cover material will protect the primary liner from physical damage from stresses and disturbances from overlying wastes, cover materials, and equipment operations. *

   ii. Describe how the protective cover will allow the continuous and free flow of leachate. Describe the possibility and effects of subsidence should it occur. *

* SEE NOTE (1) ON PAGE 12.

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6. Leachate Collection System within Protective Cover:

   i. Provide a detailed description of the physical and structural aspects of the proposed leachate detection system. Include information on the size, types, dimensions and depths of all materials used, slopes, calculations on anticipated bearing loads (wastes and equipment), and leachate detection capabilities. Indicate which drawings and sections of the specifications contain the information on layout and material requirements.

   ii. Provide a description of how the system will detect, collect, and transmit leachate. Briefly describe the leachate treatment facilities and approvals obtained.

   iii. Describe the methods for cleaning and maintaining pipes, including methods for testing installed pipes for leakage.

7. Cap:

   i Provide a detailed description of the chemical and structural characteristics of the materials to be used for the final cover. Be sure to indicate the minimum and maximum size of materials allowed, sieve sizes, USDA Texture Class, and any other significant distinguishing characteristics.

   ii Provide a description of how the materials are to be placed and compacted, with details on maximum slopes, minimum depths, and acceptable bearing loads.

* SEE NOTE (1) ON PAGE 12

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PART III. Liner Installation Plan

Attach a detailed explanation of the procedures and equipment to be used in site preparation and placement of each phase of the liner system. To the extent possible, outline the manpower requirements and the time required for each phase of installation. Be sure to reference applicable drawings and specifications which contain information relevant to each phase of the liners construction. As a minimum, the following are to be addressed:

A. Subbase:

1. Information on the maximum depth of earth moving activities and the site preparation procedures to be followed prior to the installation of any subbase materials.
2. Information on the selection of subbase materials, their grading and tests to be conducted to ensure uniformity.
3. Information on how the subbase materials are placed, graded, compacted, and tested for proper installation.

B. Liners:

1. For synthetic liners, provide all information supplied by the manufacturer as to required handling and installation procedures. SEE SECTION 3.1.13 AND APPENDIX IIC
2. For non-synthetic liners, information on the minimum acceptable characteristics (i.e. moisture content, etc.) are to be provided.
3. For non-synthetic and non-synthetic liners, information as to the equipment required, pre and post installation testing is to be provided.

C. Leachate Detection and Collection Zones:

1. Provide details on how the detection and collection zones will be installed with specific information as to what materials and construction techniques will be used to construct each zone.
2. Describe the sequence of construction and equipment used.
3. Describe the sequence for installing the sump and all monitoring or gas venting facilities.

D. Protective Cover:

1. Describe where the cover materials will come from, and how they are transported and placed at the site.
2. Provide details on how the cover materials will be routinely tested for conformance with design specifications.

E. Final Cover and Grading:

1. Provide a detailed description of how the final cover material is to be placed, compacted, and graded.
2. Describe the proposed final layout for the area with specific reference to any drainage facilities which will remain.

F. Attenuating Soil Base. (Class III Residual Waste Landfills)

1. Describe the Class of soils to be used as classified by the United State Department of Agriculture.

* SEE NOTE (1) ON PAGE 12.

2. Indicate where in the specifications and quality control procedures the requirements for attenuating soil, as contained in Section 288.624(b) of the residual waste regulations, are contained.

3. Describe the proposed sequence for placement of waste and attenuating soils.

G. Highwalls:

1. Describe how the liner or barrier materials will be installed to prevent the migration of leachate from the disposal area.

2. Provide information on each type of barrier material to be used and its minimum thickness. Include appropriate information on the physical and chemical characteristics of the material, and proof the material is not adversely affected by solid waste, leachate, or its constituents.

3. Provide detailed information on the different seams or outcrops at the proposed site and how they will be isolated from wastes. *

4. Explain how groundwater and surface water drainage will be controlled and eliminated.

5. Submit a plan for controlling damage from subsidence or the collapse of highwalls.

H. Limitations:

1. Provide appropriate information on any land use restrictions or limitations that should be followed during and after closure of the facility.

* See note 1 on page 12.

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Part IV. Compatibility of Liner to Leachate:

A sampling plan for each component of the liner system, including sample size, methods for determining sample locations, sampling frequency, acceptance and rejection criteria, and methods for ensuring that corrective measures are implemented is to be included with this form.

A. Information must be submitted which demonstrates that leachate will not adversely affect the physical or chemical characteristics of the liner system, or inhibit the liner's ability to restrict the flow of solid waste, solid waste constituents, or leachate.

Test Method Used: _____

Results of Liner Compatibility Tests are:

1. Exposure Period (days) _____
2. Temperature of Solution _____
3. Source of Representative Sample of Leachate _____
4. Type of Compound and Construction (Liner Classification: Thermoplastic, Fabric Reinforced, etc.) _____
5. Tensile Properties:
   a. ASTM Method _____
   b. Type of Specimen _____
   c. Speed of Test _____
   d. Values to be Reported: _____
6. Tear Resistance:
   a. ASTM Method _____
   b. Type of Specimen _____
   c. Speed of Test _____

B. Attach a copy of the chemical analysis of the leachate used in determining the above results.

C. Where appropriate, attach an analysis of the current leachate emanating from this landfill.

* AS DESCRIBED IN SECTION 3.1.13 COMPATIBILITY TESTING WOULD BE PERFORMED ON THE LINER MATERIALS SELECTED DURING FINAL DESIGN.

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Part V. Properties of Synthetic Liners

Supply the following physical, chemical, mechanical, and thermal properties for liners, based on ASTM methods where appropriate. Additional information may be submitted.

	Results with Units of Measurement	ASTM Method
1. Thickness		
2. Tensile Strength at Yield		
3. Elongation at Yield		
4. Elongation at Break		
5. Modulus of Elasticity		
6. Tear Resistance		
7. Impact Resistance		
8. Puncture Resistance		
9. Seam Strength (% of Liner Strength)		
10. Ultraviolet Light Resistance		
11. Operating Temperature Range		
12. Permeability		
13. Soil-to-Liner Friction (Angle in Degrees)		
14. Ozone Resistance		
15. Water Vapor Transmission		
16. Coefficient of Linear Thermal Expansion		
17. Low Temperature/Brittleness		

SEE SECTION 3.1.13, APPENDIX II D AND APPENDIX II E

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SEE NOTE 1 ON PAGE 12
ALSO SEE SECTION 3.1.13
AND APPENDIX 11C.

Part VI. Quality Assurance Plan for Construction and for Installation of Liners.

The following information shall be submitted on separate pages and referenced to the appropriate section. For each Section A summary table is to be provided which explains the procedures, the frequency for each test, and the pass/fail criteria which must be met.

A. Qualifications of independent QA personnel (describe experience and training).

B. Subbase

1. Provide design summary of procedures used to assure objectives are met:

   a. Outline tests and observations to ensure quality of compacted fill.

   b. Explain observations to ensure removal of objects or undesirable materials.

   c. Discuss observations and tests that ensure that the surface is compacted, smooth, uniform, and consistent with design grades.

   d. Summarize surveying to ensure that facility dimensions, side slopes, and bottom slopes are as specified in design.

   e. Summarize review of Quality Control information.

C. Non-synthetic Liners

1. Discuss inspection procedures of liner materials and test fill compaction. Properties to be tested should include: permeability, soil density/moisture content relationships, maximum clod size, particle size distribution, natural water content, Atterberg limits.

2. Outline procedures and methods for observing and testing liner materials before and after placement to ensure:

   a. Removal of roots, rocks, etc.

   b. Identification of changes in soil characteristics causing a change in construction specifications.

   c. Adequate spreading and incorporation of water to obtain full penetration through clods and uniform distribution of the specified water content.

   d. Maintaining optimum water content throughout wet and dry periods and during construction.

D. Synthetic and Geosynthetic Liners

Outline Procedures For:

1. Inspection of product quality, the review of manufacturers control procedures and any other observations related to transporting, storing, and handling.

2. Inspection of foundation preparation and equipment.

3. Observations of liner placement.

4. Need and availability of manufacturers representative.

5. Observations of weather conditions.

SEE NOTE 1 ON PAGE 12
ALSO SEE SECTION 3.1.13
AND APPENDIX 11C.

6. Observations and measurements of anchor trench to ensure that it is as specified in design drawings.

7. Observations and tests to confirm that all designed liner penetrations and liner connections are installed as specified.

8. Visual inspection for tears, punctures, or thin spots during placement.

9. Inspections during and after liner seaming.

10. Observations and tests to assure that seals around liner penetrations are of sufficient strength and are impermeable to leachate.

E. Protective Cover

Outline Procedures For:

1. Tests to ensure that the cover material meets design specifications, including permeability and clogging potential.

2. Observations that the cover material is free from objects that could damage the liner.

3. Observations to ensure that equipment used to place cover does not damage liner.

4. Measurements to ensure that entire liner is covered with specified thickness of cover material.

F. Leachate Detection and Collection Systems.

Discuss how the following activities will be conducted.

1. Observations and measurements to ensure that materials are of specified size and strength, and that pipe perforations are sized and spaced as specified.

2. Observations and tests to ensure that soils to be used are of proper size and gradation.

3. Method of placing bedding and inspection to ensure the pipes are bedded correctly and not susceptible to movement.

4. Observations and measurements to ensure that pipes are placed at specified locations, at specified grades, and are joined together as specified.

5. Observations and tests to ensure that backfilling is completed as specified in design, in all areas, including areas where a liner connects to a structure.

6. Testing of pipe joints and testing of solid wall pipes to ensure that there is no leakage.

7. Observations and tests of the granular drainage layer to ensure that the material meets the specifications of design (including permeability and clogging potential to geosynthetics).

8. Synthetic drainage layers: Observations to ensure proper placement, correct seaming, and allowable weather conditions.

9. Geotextiles: Observations of placement to ensure that specifications are followed, adequate overlap or seaming, and that there is no damage.

10. Sumps: Observations to ensure that structures are of specified dimensions, material, and capacity.

11. Mechanical and electrical equipment installation: Observations to ensure that equipment is in accordance with design specifications and manufacturer's recommendations.

G. Final Cover System

SEE NOTE 1 ON PAGE 12.

Discuss who and how following activities will be conducted:

1. Observations and tests to evaluate stability of cover system foundation.

2. Observations and testing as necessary to confirm that soil materials meet specified design.

3. Non-synthetic component: Monitor soil type, moisture content, density, compaction, lift thickness, clod size, uniformity of compaction, completeness of coverage, and permeability.

4. Tests for seals around penetrations such as gas vent pipes to ensure that they do not leak.

5. Inspections for perimeter of cover, where the soil component joins or overlies the liner system, to ensure that it is installed according to specifications.

6. Liners used in the capping system shall follow guidelines for synthetic liners.

7. Observations for a protective layer, such as a geotextile, which is placed above the liner as protection from drainage layer, to ensure proper placement to avoid damage to the liner.

8. Drainage and gas venting layer placement: The gas discharge layer is placed below the synthetic liner and the water drainage layer is placed above the synthetic liner. Guidelines for the leachate collection and detection zone will be followed. Inspections of the installation of the drainage layers around the perimeter of the cover system is important, for it is here that the system connects to the surface drainage facilities. Ensure that design specifications, particularly dimensions and slopes, are achieved. Controlled gas discharge or collection systems are checked for proper installation and function.

9. Filter layer used above or below drainage layer to stop migration or piping of fine materials should be tested for any clogging potential. During construction of filter layer, inspection will include monitoring of particle size (for soil materials) or geotextile type and certification, seaming or overlap for geotextiles, slope of surface, and coverage.

10. Topsoil layer placement: Monitor uniformity of application process, observations to ensure that soil is not overly compacted, and measurements of thickness and slope of topsoil layer.

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11. Topsoil seeding: Inspection of seeding process, measurement of tilling depth, application rate of additives should be monitored for consistency with design specifications. Application equipment will be appropriate. Verify that all vents and standpipes or other penetrations through cover are not damaged by tilling and application process. Weather conditions are to be appropriate. Post-construction: Slopes will be surveyed and any unusual depressions noted and corrected.

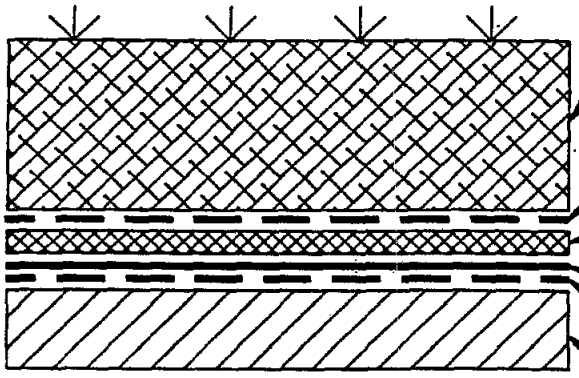
12. Review of Quality Control information.

NOTE 1: THE INFORMATION REQUIRED IN THIS SECTION (FORM 16R) WOULD BE BASED ON THE LINER MATERIALS AND CONSTRUCTION METHODS TO BE SELECTED DURING FINAL DESIGN. THIS INFORMATION WOULD BE SUBMITTED TO USEPA FOR REVIEW AND APPROVAL WHEN FINAL DESIGN IS COMPLETE AND LINER MATERIALS AND METHODS OF CONSTRUCTION HAVE BEEN SELECTED

APPENDIX 11A
COVER AND LINER SYSTEMS
FOR ON-SITE CONTAINMENT
CELL (FROM FS)

From:
FS Figure 7-7

COVER SYSTEM



2' OF SOIL CAPABLE OF SUPPORTING ADEQUATE VEGETATIVE GROWTH

NON-WOVEN GEOTEXTILE

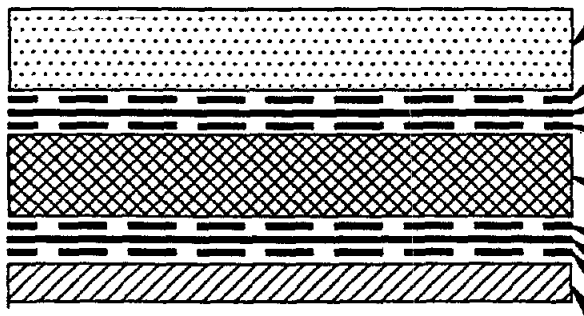
6" DRAINAGE LAYER OR GEONET

60 MIL HDPE

NON--WOVEN GEOTEXTILE

1' OF INTERMEDIATE COVER

STABILIZED SOIL & SEDIMENT



1' PROTECTIVE COVER

NON--WOVEN GEOTEXTILE

60 (OR 80) MIL HDPE

NON--WOVEN GEOTEXTILE

1' DRAINAGE LAYER

NON-WOVEN GEOTEXTILE

60 MIL HDPE

NON-WOVEN GEOTEXTILE

6" SUBBASE

LINER SYSTEM

NOTES:

1. COVER AND LINER SYSTEMS FOR ON-SITE DISPOSAL UNIT DESIGNED TO MEET FEDERAL (40 CFR 264) AND STATE (PADER TITLE 25 CHAPTER 75.264) RCRA REQUIREMENTS.

2. SOURCE: MCLAREN/HART ENVIRONMENTAL ENGINEERING CORP. PITTSBURGH, PA

TITLE

COVER & LINER SYSTEMS FOR ON-SITE RCRA CELL

PREPARED FOR

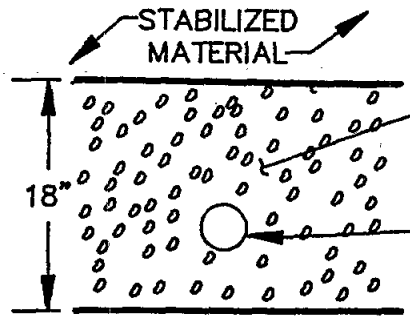
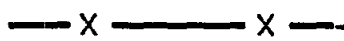
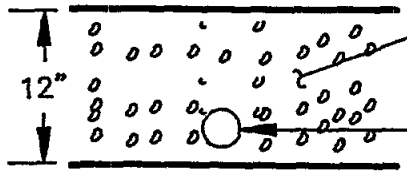
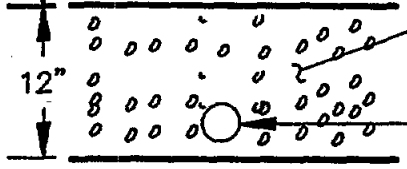
AT&T NASSAU METALS

ERM-Northeast Environmental Resources Management

SCALE NONE | DATE JULY 18, 1991 | FIGURE 4-7

514.001.02

APPENDIX 11B
CONCEPTUAL LINER DESIGN
ON-SITE CONTAINMENT CELL
(MODIFIED FS LINER DESIGN)

REGULATION	ZONE	FIGURE	DESCRIPTION
288.437 AND 288.438	LEACHATE COLLECTION ZONE WITHIN PROTECTIVE COVER		PERMEABLE SOIL (PERMEABILITY NOT LESS THAN 1.0 x 10^{-2} cm/sec); 6" DIAMETER PERFORATED PIPE
288.436	PRIMARY LINER		60 mil HDPE
288.435	LEACHATE DETECTION ZONE		PERMEABLE SOIL (PERMEABILITY NOT LESS THAN 1.0 x 10^{-2} cm/sec); 4" DIAMETER PERFORATED PIPE
288.434	SECONDARY LINER		60 mil HDPE ***
288.433	SUBBASE		SUBBASE SOIL (PERMEABILITY NOT GREATER THAN 1.0 x 10^{-5} cm/sec)
288.432(a)(2)	GROUND WATER DRAINAGE LAYER **		PERMEABLE SOIL; 4" DIAMETER PERFORATED PIPE

NOTES:

* SUBBASE DEPTHS:
  FOR NORTHEAST CELL AREA: DEPTH = 6 INCHES
  FOR SHALE PIT CELL AREA: DEPTH = 8 FEET

** GROUND WATER DRAINAGE LAYER PROPOSED FOR SHALE PIT AREA ONLY

*** COMPOSITE LINER CONSTRUCTED OF BENTONITE LAYER ATTACHED TO HDPE GEOMEMBRANE

TITLE

CONCEPTUAL LINER DESIGN
ON-SITE CONTAINMENT CELL
C&D RECYCLING SITE

PREPARED FOR
AT&T NASSAU METALS

ERM-Northeast
Environmental Resources Management

SCALE	FIGURE
NONE	APPENDIX 11B

DRAWN	JOB NO.	FILE NAME	DATE
S.G.	631.002.03	APPND11B	3/24/93

APPENDIX 11C
SAMPLE LINER INSTALLATION
QUALITY ASSURANCE AND
QUALITY CONTROL PLAN

From:
Quality Control Manual and
Quality Control Update
Gundle Lining Systems, Inc.
Houston, Texas

QUALITY CONTROL MANUAL

1. QUALITY CONTROL

1.1 Company Statement

This quality control manual is intended to satisfy the basic quality control needs of the company.

The procedures herein must be adhered to at all times. This supercedes all previous procedures relating to quality control. Personnel may only deviate from these procedures if instructed to by the President of the company.

These procedures apply to all production. They should be updated at least annually. Conformance to procedures will be monitored by an audit at least annually.

2. OBJECTIVE

2.1 The objective of this manual is to lay down procedures:

a. For achieving a structured approach towards attaining the high quality of the products demanded by customers, and,

b. To satisfy the Company's need for systematic procedures operated by an effective and efficient quality control department within the organization.

3. SAMPLING FREQUENCY

3.1 Raw Materials - A sample from each hopper compartment will be tested.

3.2 Finished Goods - Products must be sampled at least twice per shift. Samples must be taken even if they cannot be tested until a later date. Sampling is done by production personnel.

4. TESTING PROCEDURE

4.1 Raw Material testing involves short term testing aimed at "fingerprinting" the material supplied. Every resin demonstrates its own individual characteristics that are determined by its chemical make-up and molecular weight. For reference purposes, density and melt index serve to identify the material as being acceptable or not. A visual inspection for contaminants is also performed.

4.1.1 The melt index (ASTM D1238) is a numerical qualification of the molecular weight of the material as demonstrated by flow through a .0825 inch (2.09mm) diameter orifice at constant pressure and temperature. Lower molecular weight materials flow faster than higher molecular weight materials, thus giving an exact value particular to any grade of resin.

4.1.2 The density of the material (ASTM D1504) is expressed as the weight per unit volume of the material at 23 degrees C. The density of the material serves as a reference to a range of properties including tensile strength, hardness, and chemical resistance.

4.1.3 A visual inspection of the sample is performed to identify any possible contaminants.

4.2 Finished goods testing involves short and long term testing aimed at confirming the physical properties of the material.

4.2.1 Tensile and elongation properties are determined according to ASTM D638. The tensile strength at yield and break is determined and must meet pre-defined specifications. Elongation at the yield point as well as the ultimate elongation of the material is determined and must meet pre-defined specifications.

Tensile testing is performed parallel and transverse to the production direction. A 2-inch (50.8mm) per minute testing rate is used in conjunction with type IV tensile specimens.

4.2.2 The thickness of the material is tested according to ASTM D1593 and D374. Measurements are taken across the width every seven inches and along the length of the sheet every five minutes.

4.2.3 The carbon black content is monitored according to ASTM D1603. Samples of the liner material are weighed and then pyrolyzed under nitrogen which vaporizes the polyethylene, leaving the carbon black as a residue. The weight of the carbon is taken and the percent carbon black content calculated. Maintaining a minimum carbon black content of 2% ensures resistance to ultraviolet exposure.

4.2.4 A visual inspection is made of the liner material to ensure that it is free of pores, pinholes, or other detrimental defects.

4.2.5 Environmental stress crack testing is performed according to ASTM D1693. Notched specimens of sheeting are bent 180 degrees and tested at 50 degrees C in 10% igepal CO-630 solution. No failures should occur.

4.2.6 From the daily production testing, a quality certificate is issued by the laboratory.

4.3 Field Quality Control testing involves both non-destructive and destructive testing. The non-destructive testing is primarily centered on determining "watertightness", whereas the destructive testing is based on the ASTM D4437 test method.

4.3.1 One inch strips cut with the weld centrally located are tested by stressing the weld in a "shear" configuration. That is, the top sheet is stressed in relation to the bottom sheet in a direction away from the weld. A pass result occurs when the upper or lower sheet yields. A fail result occurs when the weld fails.

4.3.2 One inch strips cut with the weld centrally located are tested by stressing the top sheet in relation to the overlapped edge of the lower sheet in an effort to peel the weld away. A pass result occurs when the sheeting yields. A fail result occurs when the weld peels.

4.3.3 A sample weld shall be made twice during each shift with each welding machine. Samples from the weld shall be tested in shear and peel, and no welder may start work until the sample weld has been approved.

4.3.4 A visual examination of the seam provides the most useful means of ensuring watertightness. As Gundle fusion welds are visible on the surface, any suspect areas, brakes, or holes in the weld are easily seen and marked for repair.

4.3.5 Destructive shear and peel tests shall be done by random selection of an actual field weld no less than one sample per 500 feet (150 meters) of weld.

4.3.6 Vacuum testing follows no specific standard. A glass-faced suction box, typically 3 feet (1 meter) long and wide enough to cover the weld, is placed over a section of the seam which has been wet with a soap solution. Suction is applied to the seam and any leaks are demonstrated by the formation of bubbles. Holes are marked and repaired.

QUALITY CONTROL UPDATE

TECHNIQUE, QUALITY CONTROL & FIELD SEAM TESTING PROCEDURE

1. Field Seams

Gundle uses two methods for seaming flexible membrane liner material in the field: the hot wedge (fusion) welding process and our patented fillet-extrusion welding process.

2. Welding Equipment

The welding equipment used shall be capable of continuously monitoring and controlling the extrusion/fusion zone. The fillet-extrusion welding device provides continuous dynamic integration of the extrudate into the sheet material through the means of rotating tips in the nozzle. The composition of the extrudate (welding rod) is identical to the flexible membrane liner. This method of seaming is applied for all tees, patches, "fishmouths", and detail work. The fusion welding device employs a hot wedge (hot shoe) and compression. The system lifts both layers of flexible membrane liner off the subgrade and fusion is brought about by melting the sheets against the hot wedge and compressing the two melted surfaces together resulting in a total integration of the polymers.

3. Weld Quality Control and Testing

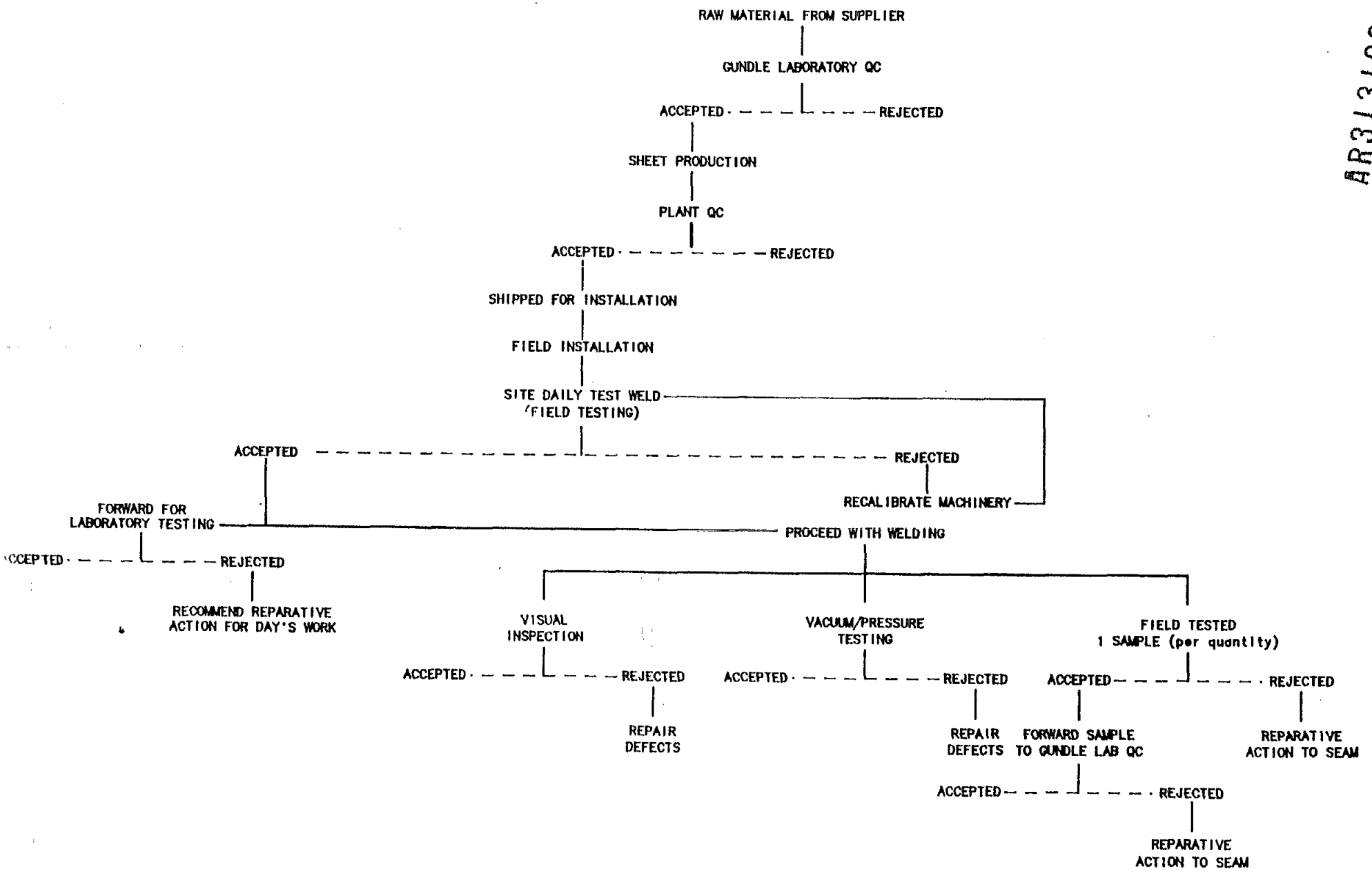
3.1 A test weld, three (3) feet [one (1) meter] long, from each welding machine shall be run each day prior to liner welding and under the same conditions as exist for the liner welding. Samples of weld shall be cut from the test weld and pulled by hand in the peel mode. The weld should exhibit a film tearing bond (FTB). The test weld shall be marked with date and welding machine number. The weld sample shall be kept for subsequent testing on laboratory tensometer equipment in accordance with the applicable ASTM tests.

3.2 All welds, on completion of the work, shall be tightly bonded. Any membrane area showing injury due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of Gundline membrane.

3.3 A quality-control technician shall follow behind each seam crew and perform a visual inspection of the seamed area. Defective seams should be marked and repaired in accordance with Gundle's published repair procedure.

3.4 No "fish-mouths" shall be allowed within the seam area. Where "fishmouths" occur, the material shall be cut, overlapped, and an overlap-extrusion weld shall be applied.

3.5 All field seams (100%) shall be tested non-destructively. Fillet-extrusion welds are tested with a vacuum chamber. Hot wedge welds are pressure tested, pressurizing the gap created by the split face design of the hot wedge.


RAW MATERIAL FROM SUPPLIER
GUNDLE LABORATORY QC
ACCEPTED
REJECTED
SHEET PRODUCTION
PLANT QC
ACCEPTED
REJECTED
SHIPPED FOR INSTALLATION
FIELD INSTALLATION
SITE DAILY TEST WELD
(FIELD TESTING)
ACCEPTED
REJECTED
RECALIBRATE MACHINERY
FORWARD FOR
LABORATORY TESTING
PROCEED WITH WELDING
CCEPTED
REJECTED
RECOMMEND REPARATIVE
ACTION FOR DAY'S WORK
VISUAL
INSPECTION
VACUUM/PRESSURE
TESTING
FIELD TESTED
1 SAMPLE (per quantity)
ACCEPTED
REJECTED
ACCEPTED
REJECTED
ACCEPTED
REJECTED
REPAIR
DEFECTS
REPAIR
DEFECTS
FORWARD SAMPLE
TO GUNDLE LAB QC
REPARATIVE
ACTION TO SEAM
ACCEPTED
REJECTED
REPARATIVE
ACTION TO SEAM

QUALITY CONTROL CERTIFICATE

GUNDLINE HD

MATERIAL _____ DATE _____

BATCH # _____ PROJECT _____

ROLL # _____ _____

TEST PARAMETER	REQUIRED SPECIFICATIONS	TEST RESULTS	ASTM TEST METHOD
Thickness, mils			D 1593
Density, gms/cm^3			D 1505
Tensile Strength (psi) Yield Break			D 638 Type IV 2 ipm
% Elongation, Break			D 638

CERTIFIED BY:

_____

Darlene Phouangsavanh
Lab Supervisor

AR313110

LABORATORY REPORT#_____

DATE_____

SUBJECT:

Resin quality control_____Batch #_____

TEST METHOD:

Melt Index	ASTM D1238 E & P
Density	ASTM D1505

TEST RESULTS:

Melt Index, E	_____g/10 min.
P	_____g/10 min.
Density	_____g/cm3

CONCLUSION:

CERTIFIED BY:

_____

Darlene Phouangsavanh
Lab Supervisor

SITE WELDING QUALITY CONTROL REPORT

PROJECT _____ CONTRACT # _____

SITE _____ DATE _____

MATERIAL _____ THICKNESS _____

Weld Reference _____

Weld Inspection _____ Observations _____

Weld Re-Inspection _____ Observations _____

Sample Weld Location _____

Sampled By: _____

Sample Weld Test Results

Sample Weld #	Specimen	Peel Results
	1	
	2	
	1	
	2	
	1	
	2	

CERTIFIED BY:

_____

Lab Technician

APPENDIX 11D
SAMPLE SYNTHETIC LINER
MATERIALS (HDPE) SPECIFICATIONS

From:
Standards Specifications For
HDPE Liner Materials
Gundle Lining Systems, Inc.
Houston, Texas

STANDARD SPECIFICATIONS FOR HDPE LINING MATERIAL

1. SCOPE

These specifications describe High Density Polyethylene (HDPE) Lining Membranes. The supply and installation of these materials shall be in strict accordance with the Engineer's specifications and engineering drawings and be subject to the terms and conditions of the contract.

2. MANUFACTURER'S EXPERIENCE

The manufacturer of the lining material described hereunder shall have previously demonstrated his ability to produce this membrane by having successfully manufactured a minimum of one hundred million square feet (9,290,226 meters) of similar liner material for hydraulic lining installations. The manufacturer must be listed by the NSF (National Sanitation Foundation) Standard 54.

3. LINING MATERIAL

3.1 The new membrane liner shall comprise HDPE material manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

3.2 The Contractor shall, at the time of bidding, submit a certification from the manufacturer of the sheeting, stating that the sheeting meets physical property requirements for the intended application.

3.3 The liner material shall be so produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired using the extrusion fusion welding technique in accordance with the manufacturer's recommendations.

3.4 The lining material shall be manufactured a minimum of 22.5 feet (6.8 meters) seamless widths. Labels on the roll shall identify the thickness, length, and manufacturer's roll number. There shall be no factory seams.

3.5 The liner material shall meet the specification values according to the specification sheet for HDPE.

4. FACTORY QUALITY CONTROL

4.1 Raw Material

All compound ingredients of the HDPE materials shall be randomly sampled on delivery to the HDPE manufacturing plant to ensure compliance with specifications. Tests to be carried out shall include Density ASTM D1505 and Melt Index ASTM D1238, Condition E.

4.2 Manufactured Roll Goods

Samples of the production run shall be taken and tested according to ASTM D638 to ensure that tensile strength at yield and break, elongation at yield and break meet the minimum specifications. A quality control certificate shall be issued with the material.

4.3 All welding material shall be of a type supplied by the manufacturer.

5. INSTALLATION

5.1 Area Subgrade Preparation

Surfaces to be lined shall be smooth and free of all rocks, stones, sticks, roots, sharp objects, or debris of any kind. The surface should provide a firm, unyielding foundation for the membrane with no sudden, sharp or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed. The installation contractor shall certify in writing that the surface on which the membrane is to be installed is acceptable before commencing work.

5.2 Contractor Approval

The installation of the HDPE must be done by the manufacturer using the manufacturer's extrusion or hot wedge welding equipment and installation methods. All supervisors overseeing the liner installation must have ten million square feet of supervisory liner experience. All field technicians must have over one million square feet of seaming experience.

5.3 Field Seams

Individual panels of liner material shall be laid out and overlapped by a maximum of four inches (101 millimeters) for extrusion weld prior to welding or five inches (127 millimeters) for hot wedge weld prior to welding. Extreme care shall be taken by the installer in the preparation of the areas to be welded. The area to be welded shall be cleaned and prepared according to the procedures laid down by the material manufacturer. All sheeting shall be welded together by means of integration of the extrudate bead with the lining material. The composition of the extrudate shall be identical to the lining material, or all sheeting shall be welded together using the hot wedge welding system.

5.4 The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the lining material so as to ensure that changes in environmental conditions will not affect the integrity of the weld.

5.5 No "fish mouths" shall be allowed within the seam area. Where "fish mouths" occur, the material shall be cut, overlapped, and an overlap extrusion weld shall be applied.

6. FIELD SEAM TESTING/QUALITY CONTROL

6.1 The installer shall employ on-site physical non-destructive testing on all welds.

6.2 A quality-control technician shall inspect each seam. Any area showing a defect shall be marked and repaired in accordance with HDPE repair procedures.

6.3 A test weld three (3) feet long [one (1) meter] long from each welding machine shall be run each day prior to liner welding and under the same conditions as exist for the liner welding. The test weld shall be marked with date, ambient temperature, and welding machine number. Samples of weld 1/4" to 1/2" (10mm to 20mm) wide shall be cut from the test weld and pulled by hand in peel. The weld should not peel. Seams should exhibit a film tear bond. The weld sample shall be kept for subsequent testing on laboratory tensometer equipment in accordance with the applicable ASTM standards. Random weld samples may be removed from the installed welded sheeting at a frequency to be agreed (e.g. 1/500' of weld).

6.4 The end user company, or his designated representative, reserves the right of access for inspection of any or all phases of this installation at their expense.

7. WARRANTY AND GUARANTEE

The manufacturer/installer shall provide a written warranty.

APPENDIX 11E
SAMPLE COMPOSITE LINER MATERIALS (HDPE AND BENTONITE) INSTALLATION SPECIFICATIONS

From:
Gundseal Installation Instructions
Gundle Lining Systems, Inc.
(Note: Gundseal is a trade name of a bentonite clay plus HDPE composite liner manufactured by Gundle Lining Systems, Inc.

GUNDSEAL

GENERAL INSTALLATION INSTRUCTIONS

EQUIPMENT

A four inch diameter (Schedule 80 or heavier pipe), 20 foot long spreader bar is attached to the bucket of a loader or fork lift. An axle bar (four inch Schedule 80 or heavier pipe) or end compression system is connected to the spreader bar. If GUNDSEAL is installed with the geomembrane side facing the subgrade, then a lightweight motorized vehicle with a trailer hitch can be utlized in conjunction with the front end loader.

PRODUCT

GUNDSEAL 20 mil rolls are 17.5 feet wide x 200 feet long. Each roll weighs approximately 3,950 lbs. GUNDSEAL is available with thicker HDPE or VLDPE sheets. However, these rolls will be shorter than 200 feet.

The product must be kept dry until covered with clay, membrane, or soil. If wet, lay out bentonite side up to dry before installation. The weight is approximately 1.1 lb./square foot.

INSTALLATION

Subgrade Preparation

Surfaces to be lined shall be smooth and free of all rocks, sharp stones, sticks, roots, sharp objects, or debris of any kind. The surface should provide a firm, unyielding foundation for the GUNDSEAL with no sudden, sharp or abrupt changes or break in grade.

Procedures

GUNDSEAL can either be installed with the geomembrane side down, facing the subgrade or with the bentonite side down, facing the subgrade. The installation procedures for these two methods are very different due to the fact that extreme care must be taken when installing the bentonite side down in order to prevent the bentonite from being scraped off the high density polyethylene sheet.

Geomembrane Side Down

Two pieces of angle iron can be clamped to the end of the GUNDSEAL sheet as illustrated in Figure 1. A chain should be attached to the upper angle iron. This chain can then be looped over a trailer hitch on a pick-up truck or other motorized vehicle which will not damage the subgrade. This vehicle will then position the GUNDSEAL in place. As the GUNDSEAL is being positioned in place, installers on both edges of the GUNDSEAL can walk the GUNDSEAL into proper alignment. These installers should be equipped with wide mouth vice grip pliers that they can use to clamp on to the edges of the GUNDSEAL sheet and guide it into place. See photograph at end of section for example of this type of installation.

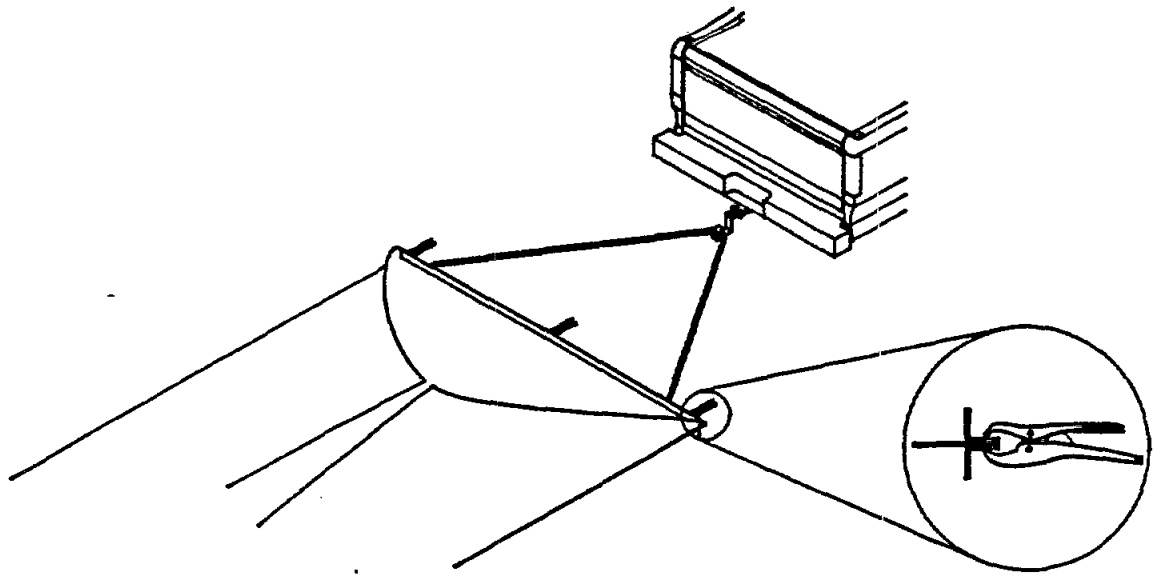


Figure 1

Bentonite Side Down

Installation of GUNDSEAL with the bentonite side down facing the subgrade is more difficult and slower. The GUNDSEAL will have to be aligned with the adjacent GUNDSEAL sheet and the loading equipment with GUNDSEAL roll on spreader bar will have to back away from the initial starting point unrolling the GUNDSEAL with the aid of installer as the equipment backs away. This type of installation is illustrated in Figure 2. Installers, equipped with wide mouth vice grips, can try to align small misalignments as the loading equipment is backing from the initial starting point. However, large misalignments will not be able to be handled by the installers due to the weight of the GUNDSEAL. Therefore, it is imperative, that at the initial starting point, the alignment be verified before the GUNDSEAL is unrolled. Once again, it is not recommended that the GUNDSEAL be pulled across the subgrade soils with the bentonite side facing downward since this action will dislodge the bentonite from the high density polyethylene sheet.

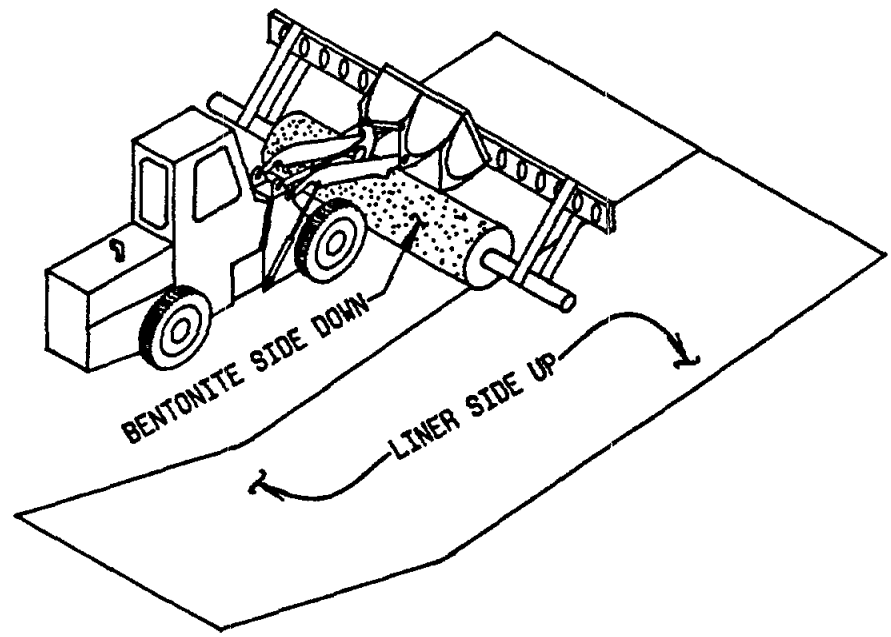


Figure 2

Cover

Cover material should be pushed perpendicular to the GUNDSEAL seams from the upper sheet to the lower sheet as illustrated in Figure 3. Care should be taken to keep cover material from separating the GUNDSEAL seams.

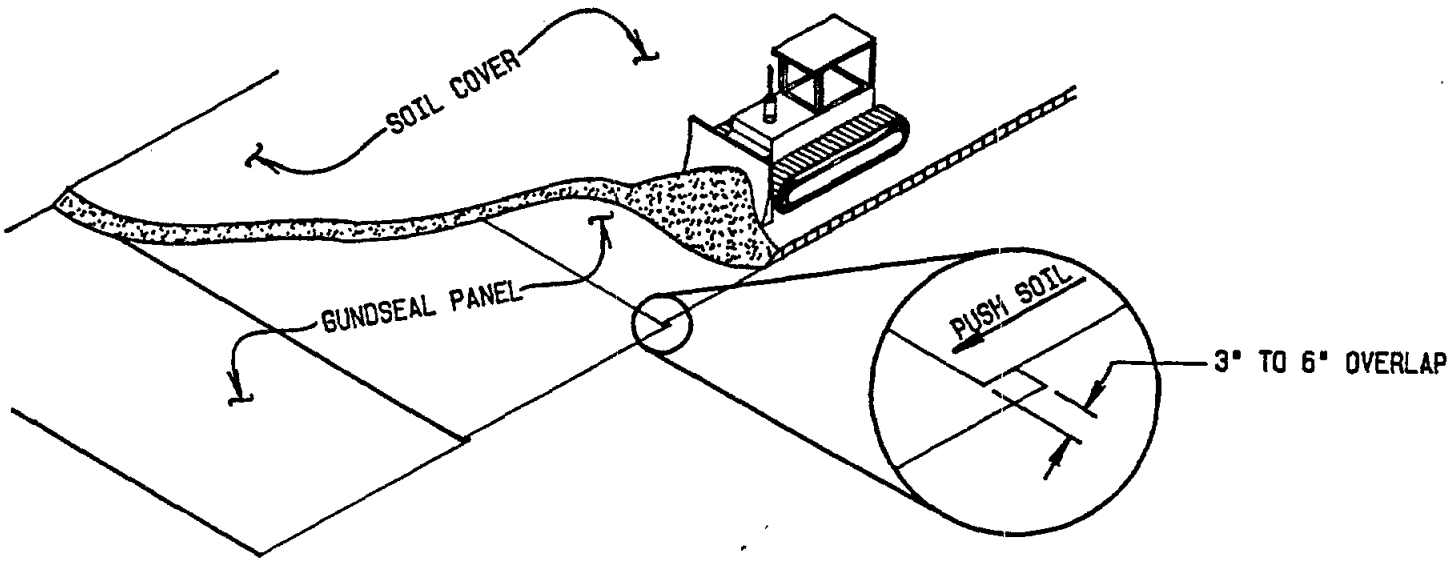


Figure 3

Crest Anchorage System

An anchor trench needs to be excavated to the lines and widths shown on design drawings prior to GUNDSEAL placement.

If the anchor trench is excavated in a clay liner susceptible to desiccation, no more than the amount of trench required for GUNDSEAL to be anchored in one day should be excavated (unless otherwise specified) to minimize desiccation potential of the anchor trench clay soils.

Slightly rounded corners should be provided in the trench where GUNDSEAL adjoins the trench so as to avoid sharp bends in the geomembrane. No loose soil should be allowed to underlie GUNDSEAL in the anchor trench.

Weather Conditions

GUNDSEAL placement should not take place during any precipitation, in the presence of excessive moisture, or in the presence of excessive winds (unless wind barriers are provided).

Seams

Overlapping is to be 3-6 inches unless engineering specifications indicate otherwise.

Patching

Patching can be accomplished with a patch that has a 12 inch overlap around the damaged area. The patch is to be tucked into place with bentonite poured over the overlap.

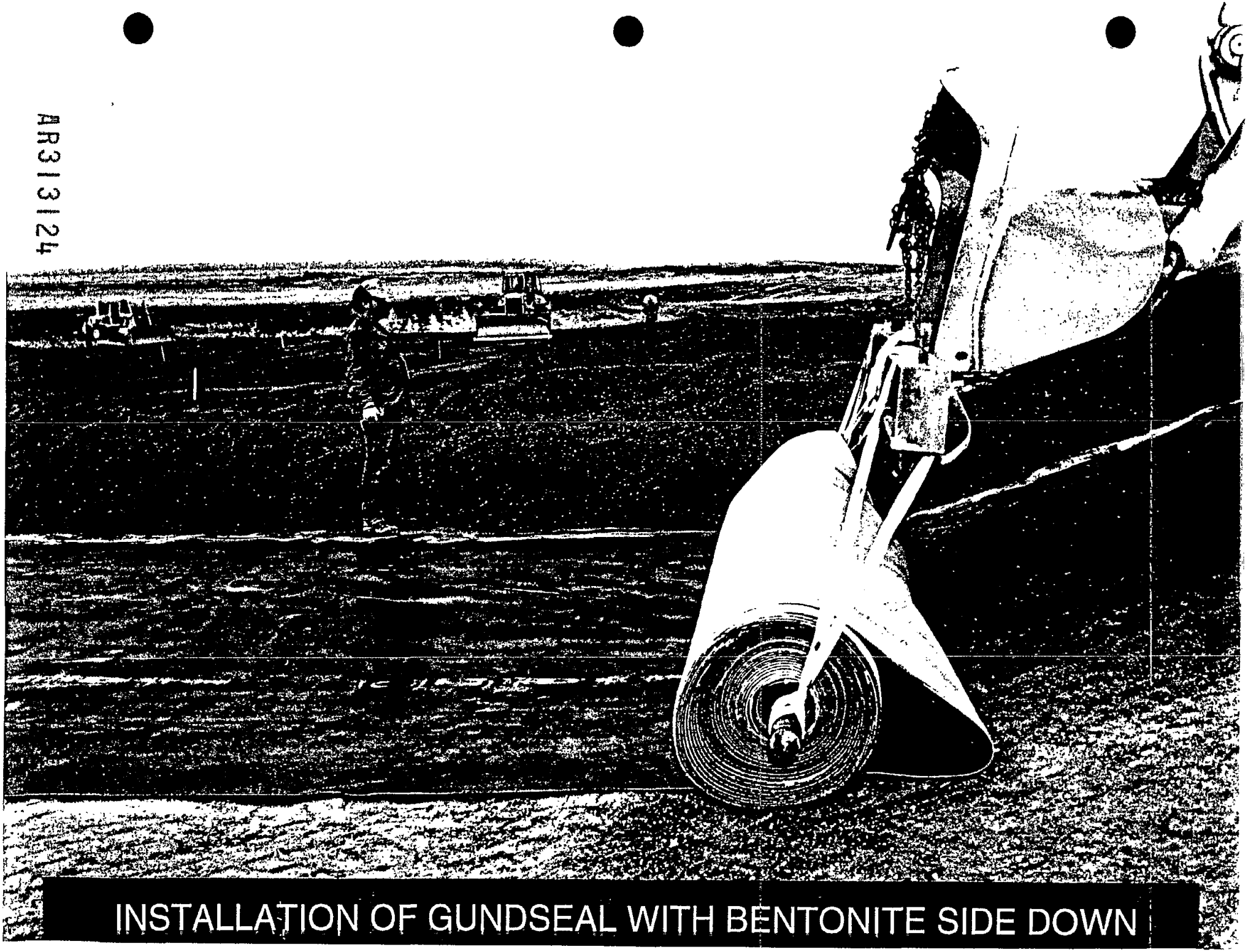
SPECIAL NOTES

GUNDSEAL needs to be stored in a dry environment on firm, level ground. The rolls should be protected by an additional waterproof cover; i.e., canvas tarp, plastic sheet, etc. The GUNDSEAL rolls should be stacked no more than two rolls high. Care should be taken to keep vehicles from making direct contact with the bentonite portion of GUNDSEAL. GUNDSEAL is shipped in plastic wrapping which needs to remain on GUNDSEAL until it is ready to be installed. It is best to install GUNDSEAL so that it is covered directly after being laid down. A sudden rain may cause rework.

Should GUNDSEAL become wet, allow air-drying before cover material is laid down. GUNDSEAL will be dry-for-installation when desiccation marks show across the bentonite surface.

Should GUNDSEAL be welded, welding is to be performed only by Gundle Lining Construction Corp. or an approved Gundle contractor and per the Gundle Quality Control Manual.

INSTALLATION OF GUNDSEAL WITH GEOMEMBRANE SIDE DOWN



INSTALLATION OF GUNDSEAL WITH BENTONITE SIDE DOWN

APPENDIX 11F
PHYSICAL AND CHEMICAL PROPERTIES OF HDPE LINER MATERIAL

From:
Gundle Lining Systems, Inc.
Gundline HD Specifications
(Note: Gundline is a trade name of a HDPE liner material manufactured by Gundle Lining Systems, Inc.)

GUNDLINE® HD is a high quality formulation of High Density Polyethylene containing approximately 97.5% polymer and 2.5% of carbon black, anti-oxidants and heat stabilizers. The product was designed specifically for exposed conditions. It contains no additives or fillers which can leach out and cause embrittlement over time.

GUNDLINE® HD SPECIFICATIONS

TYPICAL PROPERTIES*	TEST METHOD	GAUGE (NOMINAL)							
		30 mil (0.75 mm)	40 mil (1.0 mm)	50 mil (1.25 mm)	60 mil (1.5 mm)	80 mil (2.0 mm)	100 mil (2.5 mm)	120 mil (3.0 mm)	140 mil (3.5 mm)
Density. g/cc. (Min.)	ASTM D1505	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Melt Flow Index. g/10 min. (Max.)	ASTM D1238 Condition E (190°C, 2.16 kg.)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Tensile Properties (Typical)	ASTM D 638 Type IV Dumb-bell at 2 ipm.								
1. Tensile Strength at Break (Pounds/inch width)		120	160	200	240	320	400	480	560
2. Tensile Strength at Yield (Pounds/inch width)		70	95	115	140	190	240	290	340
3. Elongation at Break (Percent)		700	700	700	700	700	700	700	700
4. Elongation at Yield (Percent)		13	13	13	13	13	13	13	13
Tear Resistance Initiation. lbs. (Typical)	ASTM D1004 Die C	22	30	37	45	55	65	80	95
Low Temperature Brittleness. °F (Typical)	ASTM D746 Procedure B	−112	−112	−112	−112	−112	−112	−112	−112
Dimensional Stability. % Change Each direction. (Max.)	ASTM D1204 212°F 1 hr.	±2	±2	±2	±2	±2	±2	±2	±2
Resistance to Soil Burial. Percent change in original value. (Typical)	ASTM D3083 using ASTM D638 Type IV Dumb-bell at 2 ipm.								
Tensile Strength at Break and Yield	% Change	±10	±10	±10	±10	±10	±10	±10	±10
Elongation at Break and Yield	% Change	±10	±10	±10	±10	±10	±10	±10	±10
Environmental Stress Crack. Hours. (Min.)	ASTM D1693 (10% Igepal, 50°C)	1500	1500	1500	1500	1500	1500	1500	1500
Puncture Resistance. Pounds. (Typical)	FTMS 101 Method 2065	30	52	65	80	105	130	150	169
Coefficient of Linear Thermal Expansion. $\times 10^{-4} \frac{cm}{cm\ °C}$ (Typical)	ASTM D696	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Thermal Stability Oxidative Induction Time (OIT). Minutes. (Min.)	ASTM D3895 130°C, 800 psi O_2	2000	2000	2000	2000	2000	2000	2000	2000

**Note: All values except when specified as minimum or maximum are typical test results.*

PRODUCT DESCRIPTION

JOINING SYSTEMS

Critical to the success of any flexible membrane liner is the joining system. Gundle's Hot-Wedge Welding System and patented Extrusion Welding System are used to join individual panels of GUNDLINE HD. Request your copy of the Gundle Joining Systems Bulletin for complete details.

CHEMICAL RESISTANCE

GUNDLINE HD is resistant to a wide range of chemicals including acids, alkalis, salts, alcohols, amines, oils, and other hydrocarbons. Since combinations of chemicals of different concentrations and temperatures have different characteristics, consult Gundle for specific application details. Write for Gundle's chemical compatibility information.

SUPPLY SPECIFICATIONS

The following describes typical roll dimensions for GUNDLINE HD.

THICKNESS		WIDTH		LENGTH		AREA		ROLL WEIGHT	
mil	mm	ft	m	ft	m	ft^2	m^2	lb	kg
30	0.75	22.5	6.86	840	256	18,900	1756	2800	1272
40	1.0	22.5	6.86	650	198	14,625	1359	2800	1272
50	1.25	22.5	6.86	500	152	11,250	1043	2800	1272
60	1.5	22.5	6.86	420	128	9,450	878	2800	1272
80	2.0	22.5	6.86	320	98	7,200	670	2800	1272
100	2.5	22.5	6.86	250	76	5,625	522	2800	1272
120	3.0	22.5	6.86	210	64	4,725	439	2800	1272
140	3.5	22.5	6.86	180	55	4,050	377	2800	1272

GUNDLINE HD is rolled on 6" I.D. hollow cores.
Each roll is provided with 2 slings to aid handling on site.
Dimensions and weights are approximate. Custom lengths available on request.

Gundle Lining Systems Inc

Gundle Lining Systems Inc
19103 Gundle Road
Houston, Texas 77073
U.S.A.

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Fax: (713) 875-6010

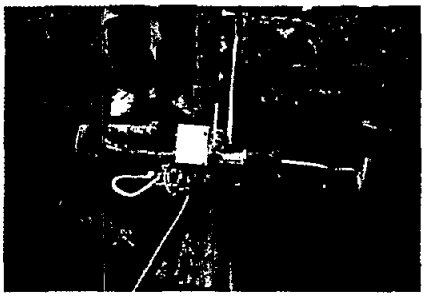
AR313127

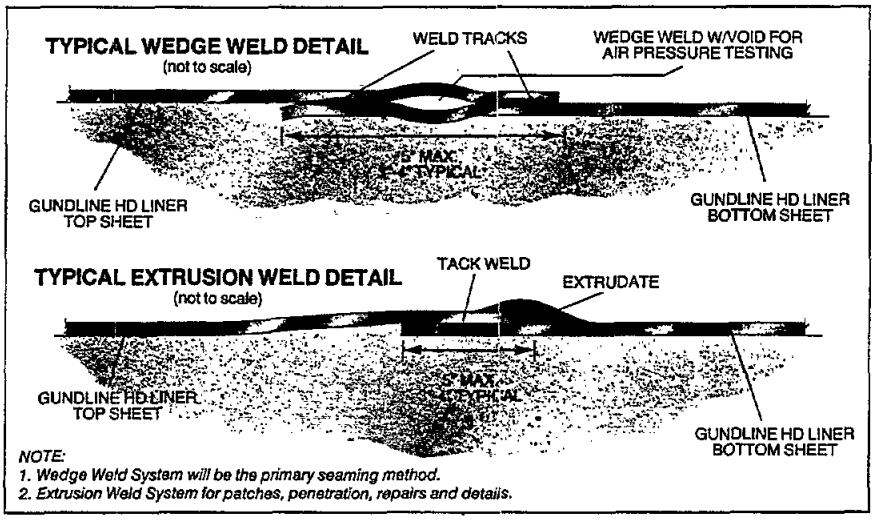
The Gundle Hot Wedge Weld: Effective And Efficient

Gundle's new generation hot wedge welders add versatility, speed and performance to Gundle's seaming capabilities. Together with the patented "mixing tip" fillet extrusion welders, Gundle offers the most advanced systems available today.

The Gundle hot wedge welder offers a number of important advantages over traditional seaming methods. As the welder propels itself along the sheets it draws a hot wedge between them. The heated sheets are then fed between a set of pressure rollers, creating a dual track seam. The Gundle hot wedge welder automatically adjusts the roller gap and wedge position to accommodate different sheet thicknesses. An air blower, mounted on the welder, directs a stream of air ahead of the path of the wedge to blow away dust particles. This air can be heated to dry or preheat the sheet during extreme cold. The Gundle welder also positions the wedge accurately at the edge of the top sheet for ease of non-destructive seam testing.

These features enable the Gundle hot wedge to weld sheets from 20 mil to 140 mil at speeds of up to 15 feet per minute. The welder has enough power to weld vertical seams, and yet, with its modern materials and innovative design, is 40% lighter than other welders, reducing operator fatigue and errors. Using appropriate temperature and speed settings, the hot wedge welded seams provide excellent results in peel and shear destructive tests.





NOTE:
1. Wedge Weld System will be the primary seaming method.
2. Extrusion Weld System for patches, penetration, repairs and details.

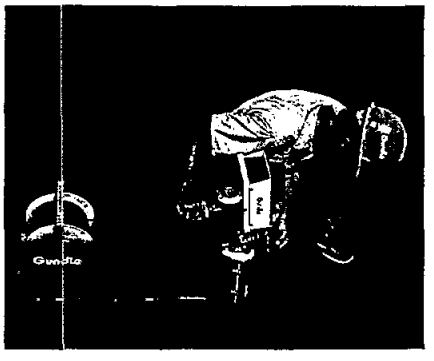
The Gundle hot wedge welder is a precision-machined assembly in which all drive components are totally enclosed and sealed from site dirt. This compact machine hardly lifts the upper sheet, which minimizes the formation of "fish mouths." Fish mouths are often caused by bulkier welding machines which stretch the top sheet. These features, together with automatically controlled temperature and speed, result in extremely consistent welds while reducing operator adjustments to an absolute minimum.

Since fillet extrusion welding is always necessary at penetrations and when patching, Gundle's hot wedge welder used alongside Gundle's patented extrusion welder with mixing action provides Gundle customers with the finest combination of welding technology available.

The Gundle Extrusion Weld: Improved Heat Transfer For Top Quality Extrusion Welding

Gundle Lining Systems' patented extrusion weld provides the combination of heating, extrudate deposition, and mixing action that results in a truly homogeneous bond between liner sheets.

Gundle's special extrusion welding gun stirs the molten extrudate against and into the liner. This mixing action greatly improves heat transfer and blends the extrudate bead into both sheets, creating a homogeneous weld. The result is a fully integrated connection through the seam. Since there is a continuous connection through the seam, and because the extruded bead is as thick as the liner sheet, the resulting seam is as strong as the sheet itself. Due to the extremely efficient heat transfer of Gundle's



patented mixing action, installations welded at 15°F have provided the same high quality test results as installations welded at 70°F.

The Gundle extrusion welder extrudes the identical polymer mix from which Gundline® HD sheet is made. The high quality pipe grade HDPE extruded to form the seam, therefore, has the same excellent resistance to a wide range of waste solutions. These include metal hydroxides, salts, acids, alkalis, oils, and hydrocarbon solvents including most chlorinated hydrocarbons (along with many other chemicals). The extrusion weld system must be used for patches, penetrations, repairs, and detail work.

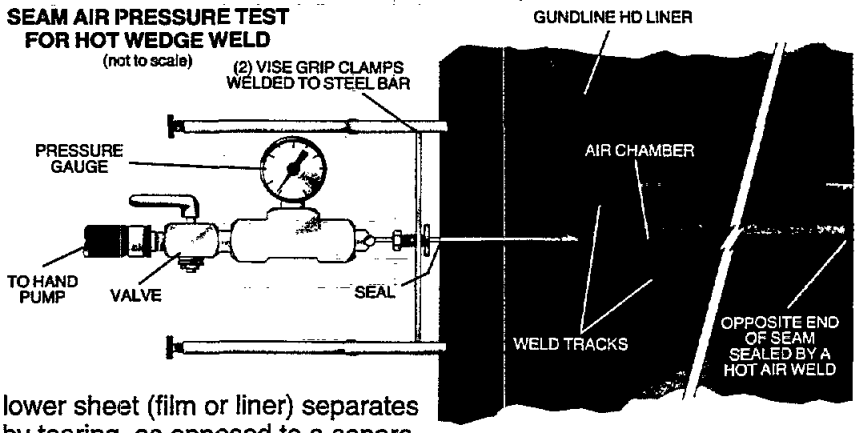
Both the Gundline extrusion weld and the Gundle hot wedge weld result in a truly homogeneous bond between the liner sheets. Therefore, there is no interface between the sheets which could be disrupted by absorbed solvents. Both Gundle seams offer the same chemical resistance as Gundle sheets and both can be used with Gundline HD, Gundline® HDT, Gundline VL, and Spectraline.

Destructive Testing At The Lab And On-Site

All Gundle seams are subjected to destructive testing. Samples cut from site welds are tested in the laboratory according to ASTM D638 (shear test) and ASTM D413 (peel test). These tests prove the quality of the Gundle welds.

Shear testing applies a tensile stress from the top sheet through the weld and into the bottom sheet. Peel testing peels the overlapped edge of the bottom sheet away from the top sheet in order to observe if separation occurs. The peel test indicates whether or not the sheets are continuously and homogeneously welded at the seam.

The important criterion in the peel test is that the test sample demonstrates what is called a Film Tear Bond (FTB). This means that as the weld is tested, the upper or lower sheet (film or liner) separates by tearing, as opposed to a separation between the top surface and bottom surface of the seam itself. A Film Tear Bond test result means the seam is good; a fully integrated weld.



Weld samples are sent by Express Mail to Gundle's laboratory in Houston from project sites. The Gundle Lab provides 24-hour turnaround for results on destructive test samples.

Gundle regularly conducts destructive seam tests at the jobsite too. This is to properly set welding conditions prior to start-up each morning and after work each work break, as well as to augment the official Gundle Lab testing of destructive seam samples.

Non Destructive Air Pressure Testing

The standard procedure for Gundle installations is to test 100% of the seam footage for leaks. With the Gundle hot wedge welder, non-destructive testing is made more efficient by air pressure testing of the gap between the "dual" wedge weld tracks on all welds 30 mils and greater. A single weld track is used on 20 mil, and an air lance or probe is used for non-destructive testing. The gap is pressurized by air injected through a needle inserted into the gap between weld tracks. Possible leaks are indicated by a loss of pressure over 5 minutes after the gap has been pressurized by a hand pump, and sealed by a valve. Very long sections of seam (up to 500 ft.) can be quickly tested for leaks, resulting in very efficient installation QC. Note that after a seam has passed a pressure test, pressure is released at the seam end opposite the pump/gauge assembly. This ensures that the seam is continuous and has been 100% tested.

Non Destructive Vacuum-Box Testing

Where air pressure testing is not applicable, Gundle technicians use a vacuum chamber to test 100% of the seamed footage. This test also confirms that no leaks are present in the seams. To perform a vacuum test, a soap solution is sprayed on top of the seam. Then a rectangular plexiglass-faced vacuum box is placed on the seam and a 5 psi vacuum is pulled in the box.

Visual inspection of Gundle extrusion welds, which are on top of the sheet, is also an important part of quality control on all Gundle installations.

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Gundle®

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APPENDIX 11G
PHYSICAL AND CHEMICAL PROPERTIES OF COMPOSITE (HDPE AND BENTONITE) LINER MATERIALS

From:
Gundle Lining Systems, Inc.
Gundseal Specifications
(Note: Gundseal is a trade name of a composite HDPE and bentonite composite liner system manufactured by Gundle Lining Systems, Inc.

An Added Barrier Of Protection From Gundle: High Performance HDPE/Bentonite Composite Landfill Liner

As concern for our environment continues to grow worldwide, the demand for reliable synthetic landfill liners is escalating. More than ever, legislation mandates these lining systems, and often requires double lining solutions.

Responding to state-of-the-art engineering strategy of designing liner systems which combine synthetic and clay layers, Gundle offers GUNDSEAL. Gundseal is a bentonite clay/polyethylene composite liner for one step deployment (usually as an addition to a conventional single or double liner system). Gundseal is made by attaching the highest quality sodium bentonite to the highest quality synthetic liner using a patented nontoxic adhesive application system. This forms a single composite liner, which takes advantage of the complementary behavior of the synthetic liner together with the bentonite clay, and forms a complete barrier.

Swelling to several times its original volume when wet, the bentonite layer in Gundseal is able to seal potential leaks in a synthetic liner under confining pressures as low as 27 psf.

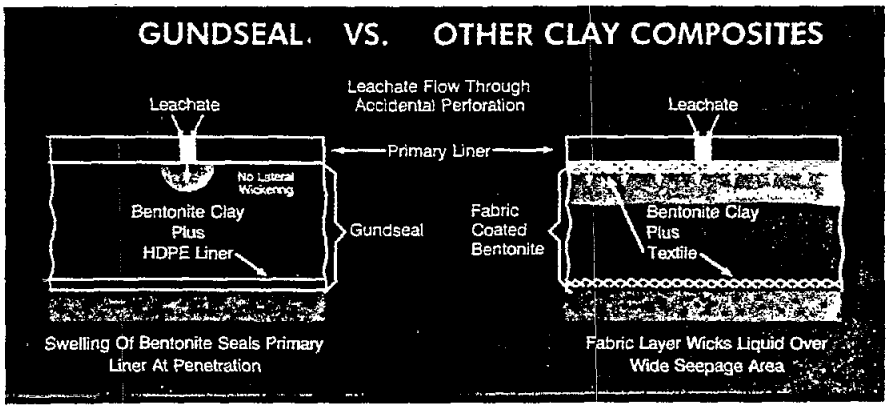
In a single composite liner application, the bentonite side is deployed face up. The primary liner is then installed on top and in direct contact with the bentonite. Any possible leakage becomes blocked by the bentonite layer with 10^{-10}cm/sec k-value followed by a polyethylene membrane with 10^{-12}cm/sec effective k-value. This means tremendous insurance is built into the liner system.

Using Gundseal, double composite liner systems can be constructed without having to compact soil on top of synthetic layers. The addition of a Gundseal blanket (bentonite face up) under a primary liner and above the drainage layer will add factors of safety in eliminating fluids in the leak detection zone. This is very attractive in light of EPA's new Response Action Plan (RAP) for leak detection systems.

Desiccation/weathering problems in standard clay caps can be solved by constructing a much less permeable, weathering- and settlement - resistant composite liner closure with Gundseal. In this case, the bentonite side of the Gundseal is deployed face down and dry against fine grained, compacted soils. The bentonite must be protected if the Gundseal is to be placed bentonite side down over coarse grained soils. These are but two of the potential applications for Gundseal.

Compared with fabric coated bentonite blankets, Gundseal will not shrink after getting wet because, unlike fabric, the membrane cannot be flexed by bentonite. And there is no fabric to transmit fluids laterally over a wide area when a Gundseal bentonite blanket is used. With Gundseal, moisture is confined to a point, not distributed over a broad area. In contrast to many fabric-coated bentonite blankets, Gundseal packs very fine mesh bentonite particles in a dense layer. There are few agglomerates or areas of loose particles.

17½-ft. wide Gundseal rolls wrapped for shipment from our Spearfish, South Dakota plant.



Gundseal HDT

Textured Gundseal combines Gundline® HDT textured high density polyethylene sheet with the high quality fine mesh grade bentonite.

Textured Gundseal provides excellent slope stability due to the textured surface of Gundline HDT. Textured surface of Gundseal is therefore ideal for steeper slopes.

GUNDSEAL HDPE/BENTONITE COMPOSITE LINER

Standard Construction

Membrane Backing	Gundline HD Membrane	20 mil*
Coating	Sodium Bentonite	1 lb./ft.^{2}*
Roll Width		17 ft. 6 in. (5.3 m)
Roll Length		200 ft. (60 m)
Roll Weight		3950 lbs.

* Other Gundle liner products and different coating weights available for special non-standard orders.

Typical Properties

Bentonite Loading	1lb./ft.^{2}
Effective Hydraulic Conductivity (Gundseal)	No Measurable Leakage
Coefficient of Permeability (Membrane)[1], ASTM E96	2.7×10^{-13} cm/sec
Hydraulic Conductivity (Bentonite)[2]	3.7×10^{-10} cm/sec
Resistance to Hydrostatic Head[3] (Ft. of water), ASTM D751	Tested to 150 ft. Head No Failure
Resistance to Water Migration Through Overlap[4]	No Measurable Leakage
Resistance to Water Migration Under Membrane[5]	Tested to 150 ft. Head No Measurable Leakage
Wet/Dry Cycles, ASTM D559	No Effect
Freeze/Thaw Cycles, ASTM D559	No Effect
Pliability: 180° bend over 1" mandrel @ -25°F, ASTM D146	10,000 cyc. No Failure

TYPICAL PROPERTIES OF GUNDLINE HD 20 MIL

(Used As Membrane For Gundseal)

Puncture Resistance, FTMS 101, Method 2065	22 lbs.
Tear Resistance, ASTM D1004	15 lbs.
Dimensional Stability, ASTM D1204	±2%
Tensile Strength, ASTM D638	
yield	2300 psi
break	4000 psi
Tensile Elongation, ASTM D638	
yield	13%
break	700%
Resistance to Soil Burial, ASTM D3083	
Tensile strength @ yield and break	±10%
Elongation @ yield and break	±10%
Environmental Stress Crack, ASTM D1693	1500 hrs.

TYPICAL PROPERTIES OF HIGH SWELLING SODIUM BENTONITE

(Used As Coating For Gundseal)

Percent Montmorillonite	80-90%
Silicon Dioxide (SiO_2)	55-64%
Aluminum Oxide (Al_2O_3)	16-22%
Ferric Oxide (Fe_2O_3)	3-6%
Sodium Oxide (Na_2O)	1-3%
Magnesia (MgO)	2-4%
Lime (CaO)	1-3%
Miscellaneous	1-5%
Water Content	5-10%
Bulk Density	77 lb/ft.^{3}
Dry Particle Size	20-50 mesh
Free Swell	20-28 ml/2 gm

1. Darcy's Law Coefficient of permeability for membrane calculated from moisture vapor transmission data (ASTM E96).
2. A 2-1/2" diameter sample was placed in a permeameter form 5 days water soaking. Permeability determined in a 15 hour time frame with a 15' falling head permeameter.
3. Membrane applied to porous stone and placed in permeameter. Pressure increased to equivalent of 150 ft. water head.
4. Two samples placed one against the other clamped between two half cyclinders of lucite and placed in a flexible wall permeameter for 25 days. Also, standing 2 ft. head of water over an 8 ft. long 3 in. overlap Gundseal seam for 5 months at U. of Texas, Austin, had no measurable leakage.
5. A 1" diameter hole was cut in the middle of a 3 1/2" diameter sample. Sample clamped in 3" diameter permeameter, 150 ft. of head applied.

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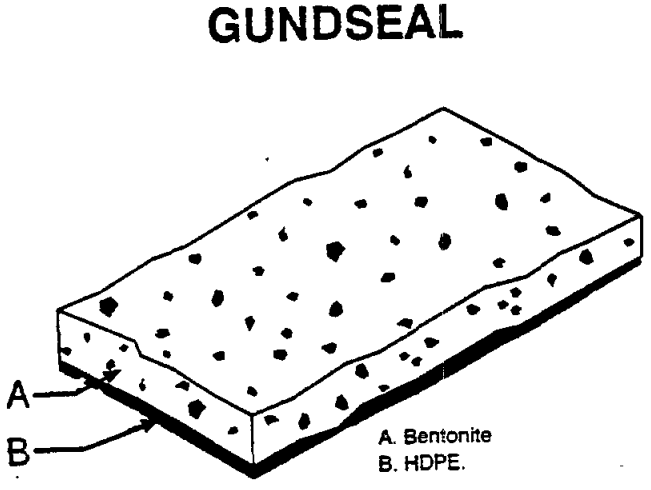
GUNDSEAL is rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Rolls are stretch-wrapped to keep dry. Each roll has an overall sheet thickness of 0.125" (3 mm). Gundseal adhesive is non-toxic and non-polluting.

GUNDSEAL - GEOSYNTHETIC CLAY LINER

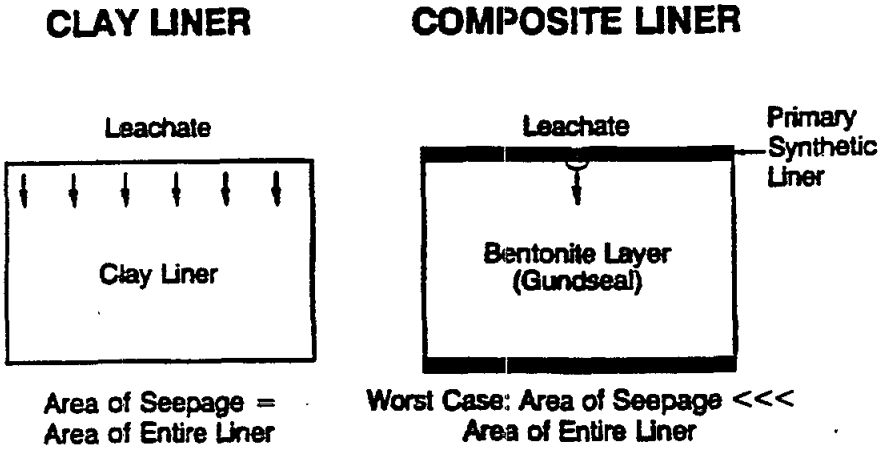
"ROLL OUT THE CLAY"

Gundseal is a geosynthetic clay liner consisting of bentonite clay and polyethylene sheet (Fig. 1). Attached to the membrane backing is one pound per square foot of high quality sodium bentonite. This composite design lets the contractor conveniently "roll out" a blanket of clay that can competitively replace or supplement compacted clay liner requirements. (Fig 2).



Self Sealing Composite Geomembrane (Gundseal).

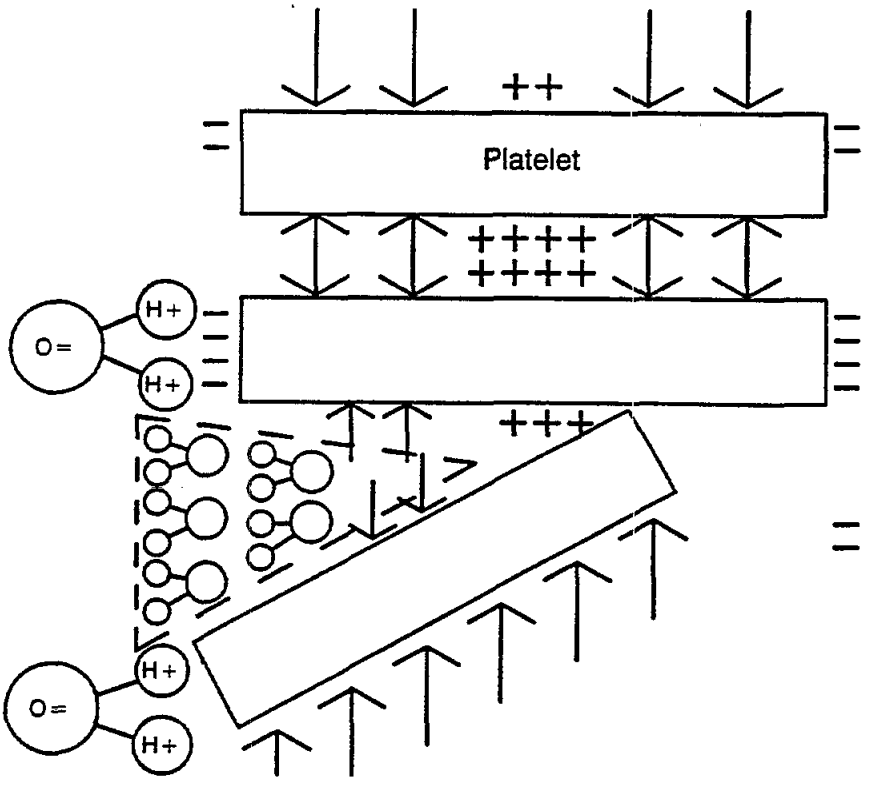
(Fig 1)



(Fig 2)

THE UNIQUE STRUCTURE OF BENTONITE

Bentonite clay consists of tightly packed ionically charged platelets. Within and between these platelets there is separation of positive and negative charges. Polar molecules, such as water molecules, are attracted by and interact with the positive and negative charges in this unique clay structure. When they come into contact with Gundseal, polar water molecules wedge their way between the bentonite platelets, causing the platelets to separate and swell apart (Fig 3). This swelling gives hydrated bentonite an extremely low permeability. The hydrated



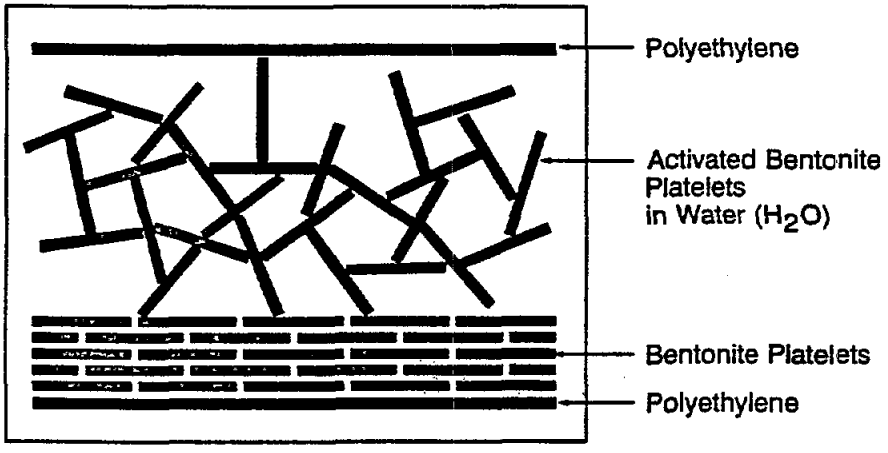
(Fig 3)

bentonite platelets form an almost impenetrable maze, which limits possible fluid migration (Fig 4). Hydrated bentonite in Gundseal achieves this very low permeability under a confining pressure of only 27 pounds per square foot (equivalent to four inches of sand cover).

FACTORY-CONTROLLED VS. FIELD COMPACTION

Gundseal offers numerous advantages over standard, field-compacted soil liners. Gundseal blankets are installed dry, eliminating the problem of soil liner dessication. Heavy equipment required for grading and compaction of clay liners is eliminated by simply unrolling Gundseal. (Fig. 5)

Furthermore, Gundseal does not require complicated, difficult to construct, soil test pads to verify field permeabilities. Much better quality control is available



(Fig 4)

Compacted Soil	Gundseal Bentonite/Synthetic "Equivalent Barrier"
Can Desiccate	Goes In Dry
Constructed with Heavy Equipment	Light Equipment Can Be Used
Requires Test Pad for Hazardous Waste Thickness	Repeated Field Testing Not Needed
	Less Permeable

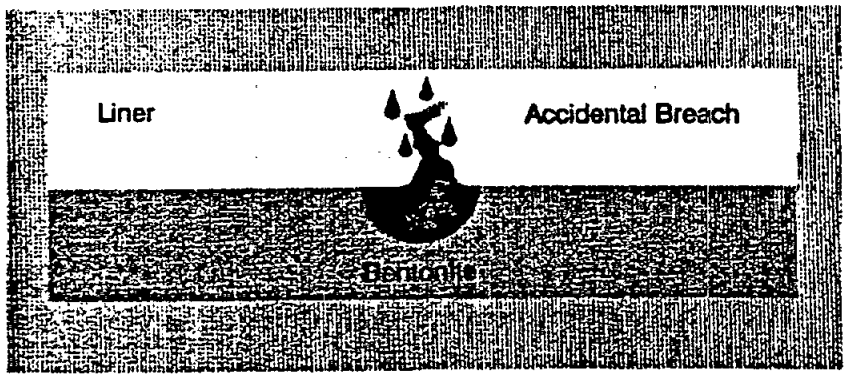
(Fig 5)

with Gundseal than that achieved in construction of soil liners. The reason for this is that Gundseal is produced in a controlled factory environment and is not subjected to field variation (material consistency, weather, etc.) which can affect soil liners. In addition, Gundseal's extremely low permeability makes up for its lack of thickness. The bentonite component of Gundseal alone has a Darcy's Law permeability coefficient of 3.7×10^{-10} cm/sec. Traditional compacted clay liners do well to obtain 1×10^{-7} cm/sec. In fact, the amount of Darcy's Law flow through Gundseal's bentonite layer is equivalent to the flow through three feet of compacted clay with a permeability of 1×10^{-7} cm/sec. This comparison does not take into account the extremely low permeability of the polyethylene component of Gundseal (effective permeability of 3×10^{-13} cm/sec.).

SEALING AN ACCIDENTAL BREACH

Should there be an accidental breach in the upper synthetic component of a composite liner system, the high quality bentonite in Gundseal will be wetted, swell into the breach, and seal the breach (Fig 6). This seal is extremely

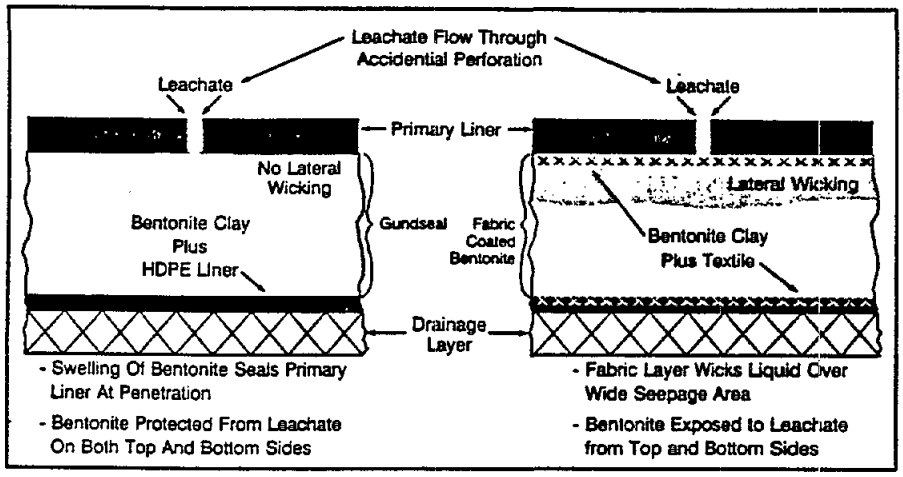
NO LATERAL MOVEMENT OF WATER



(Fig 6)

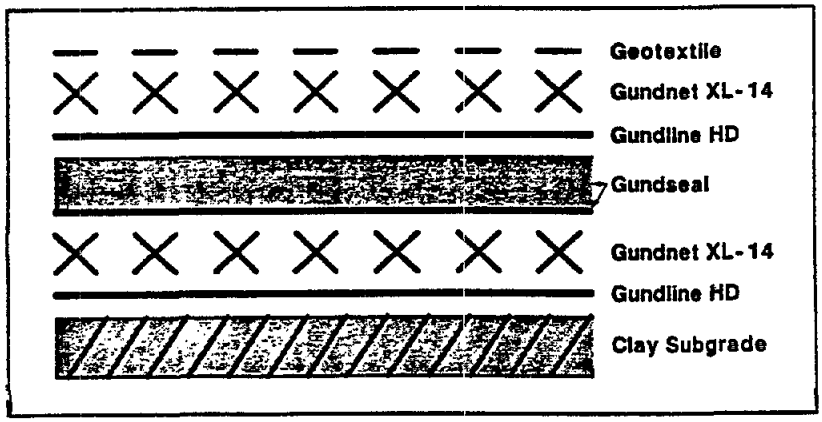
effective since there is no fabric coating, as is the case with other prefabricated bentonite clay blankets. These fabric coverings prevent development of "intimate contact" between the bentonite and the synthetic liner. The fabric encasement of other bentonite blankets also acts to "wick" the fluids and transmit these fluids over a wide area underneath the membrane (Fig 7). Placing Gundseal over (bentonite face down) or under (bentonite face up) another sheet of membrane protects the bentonite layer from fluids because a synthetic liner is on both top and bottom sides (Fig 8). Therefore the bulk of the bentonite always remains dry because fluid cannot reach it.

GUNDSEAL VS. OTHER CLAY COMPOSITES



(Fig 7)

DOUBLE COMPOSITE LINER SYSTEM USING GUNDSEAL

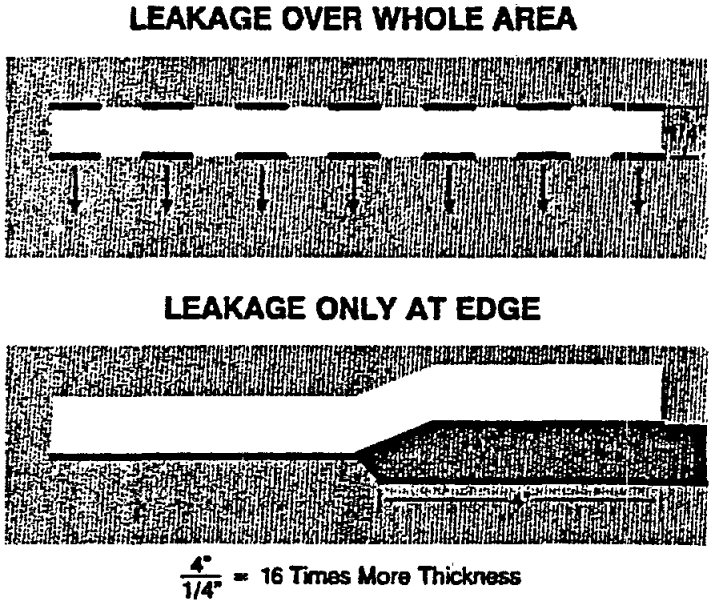


(Fig 8)

SEAMS

An overlapped Gundseal seam provides exceptional protection. The only possible path a fluid can take through a Gundseal blanket is through the overlapped seam. As with any breach, contact with a polar fluid will initiate the swelling action of the bentonite and the adhesion of intimate contact with the overlapped HDPE backing. The result is a much thicker layer of bentonite through which the fluid must pass before breaching the liner (Fig 9), than for fabric encapsulated bentonite blankets.

The product design virtually eliminates liquids from appearing in a leak detection system underneath a membrane/Gundseal composite liner. This has been confirmed by long term standing-head permeation tests described later.



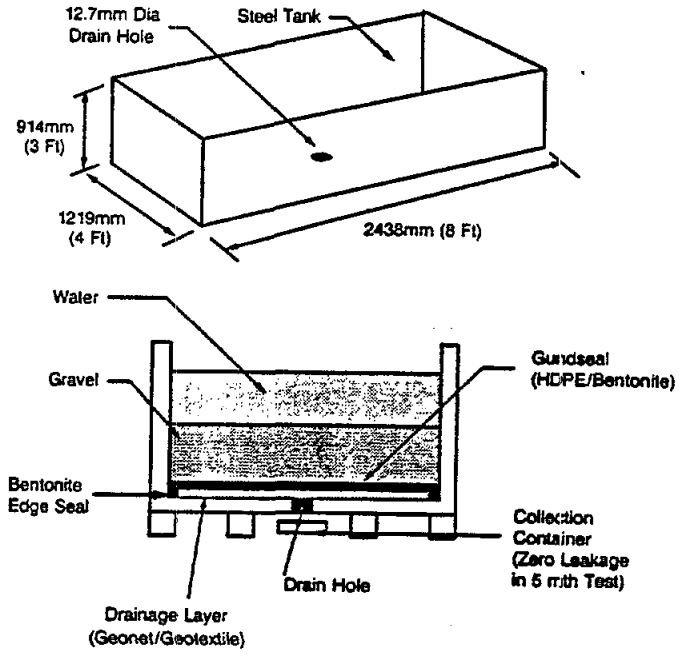
(Fig 9)

An HDPE primary liner can be seamed together directly on top of the bentonite face of Gundseal. In this way the bentonite is completely encapsulated, protecting it from a subterranean source of moisture.

A similar configuration can be achieved by placing Gundseal over top of a welded HDPE liner. Gundseal seams can be simply overlapped or extrusion welded.

UNIVERSITY OF TEXAS TESTS

A very interesting series of tests to determine permeation rates through bentonite blankets has been conducted at the University of Texas at Austin, under the direction of Dr. David Daniel. In these tests, a number of eight foot by four foot tanks were constructed with drain holes in the middle of each tank (Fig 10). Various bentonite blankets were placed over fluid drainage



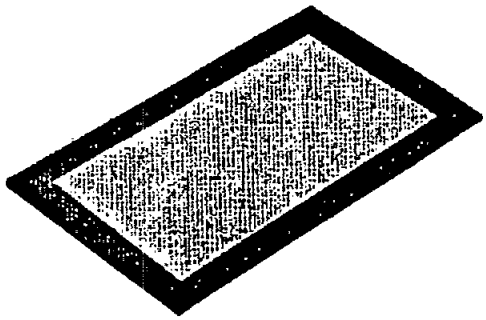
Schematic Diagram of Test to Measure Leakage through Gundseal and Gundseal Overlap Seams

(Fig 10)

systems in the bottom of these tanks. The drainage systems were set to collect any migration of liquids through the blankets. The bentonite blankets were placed in the tanks in two ways 1) as a single unit, and, 2) as two units with an overlapped seam down the middle of the tank. The edges of the blankets were sealed with bentonite. The total test system in each tank consisted of a drainage layer overlain by a bentonite blanket, followed by a one foot soil cover and then a standing head of liquid of about two feet, as illustrated. During the six month test period, the amount of fluid flowing into the drainage systems was monitored through the hole in the bottom of each tank.

The fluid detection system in the tanks containing Gundseal did not reveal any fluid movement through the Gundseal. There was absolutely zero leakage. In fact, when the bentonite blankets were uncovered, only a small amount of bentonite was noted to have hydrated along the edges and at the overlapped seam. (Fig 11).

GUNDSEAL

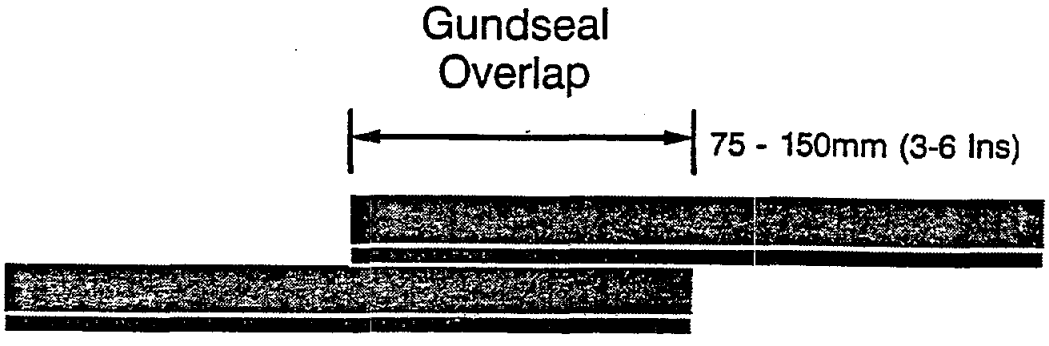


- **No Seepage through Tanks with Gundseal Bentonite Blanket**
- **Bulk of Bentonite Remained Dry**
- **Extent of Hydration only 3-4 Inches from Exposed Edges Into Bentonite**

(Fig 11)

While the bulk of the bentonite in Gundseal remained dry, the fabric encased bentonite blankets were completely hydrated. In another test, Gundseal was placed in a tank with the bentonite side facing upward. An HDPE geomembrane with holes and slits cut into it was placed on top of the Gundseal. Gravel and water were placed over the Gundseal-geomembrane liner system as described previously. The purpose of this test was to investigate the effectiveness of Gundseal when used in conjunction with a worst-case synthetic liner. After five months, the water and HDPE synthetic liner were removed to expose the Gundseal. Inspection of the Gundseal revealed that the water had moved outward from the defects and into the bentonite about three inches. Once again, the bulk of the bentonite remained dry under the standing head of liquid.

These tests demonstrated that "intimate contact" developed between the bentonite and an overlying HDPE geomembrane. In addition, these tests demonstrated the effectiveness of the overlapped seam (Fig 12). Such intimate contact does not develop between a gemembrane and a fabric encased bentonite blanket.

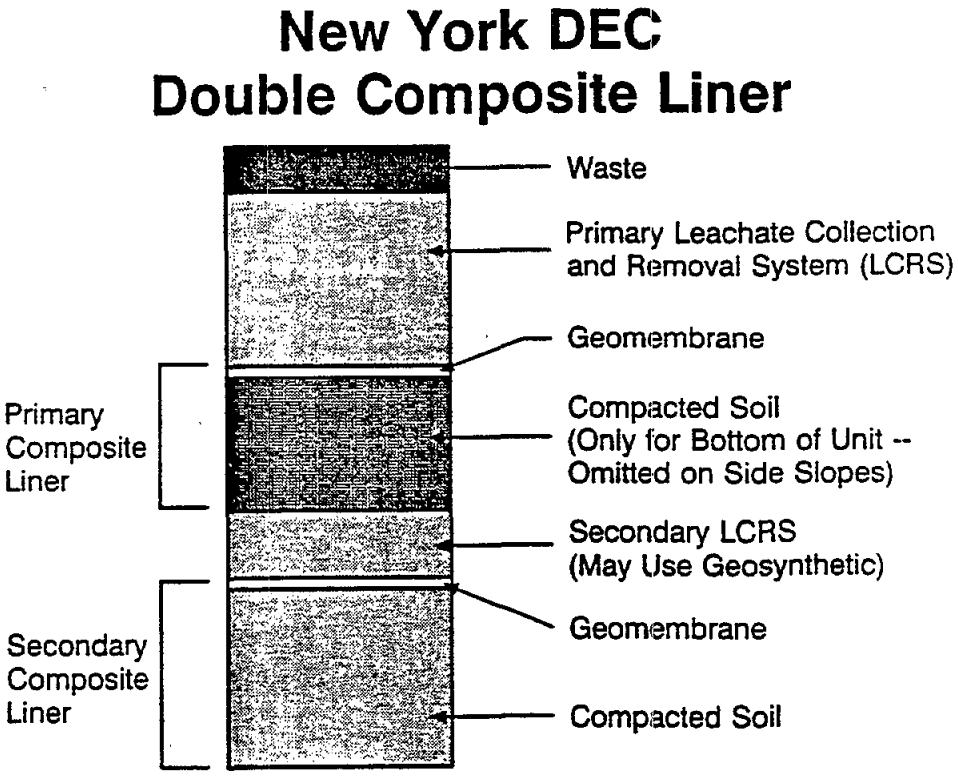


(Fig 12)

COMPOSITE LINER SYSTEMS

Because composite liner systems are the state-of-the-art in liner system design, the engineering community is experiencing, world-wide, a movement toward designing with synthetic/soil composite systems. Gundseal can supplement or replace soil liner requirements in these systems.

Many states are requiring double composite liner system for municipal waste containment (Fig 13). One problem in this approach is that proper clay compaction is difficult without potentially damaging the lower geosynthetic

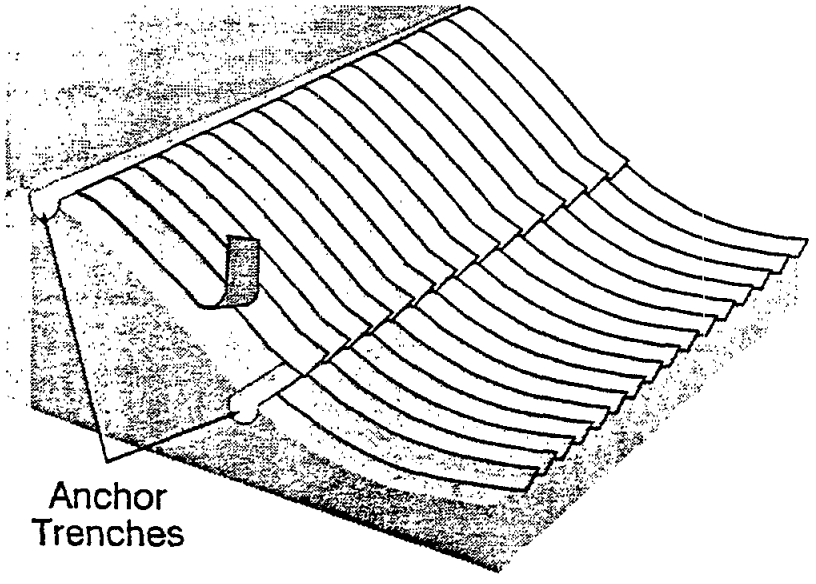


(Fig 13)

components. One way to reduce potential damage to the lower geomembrane is to use Gundseal in place of the intermediate layer of clay. In this way a composite type of liner system can still be constructed without the possibility of damaging the lower HDPE liner.

CLOSURES

Gundseal is not only available in conjunction with geomembranes for composite liner systems with the bentonite installed face up or face down. It can also supplement clay by itself in cap systems with the bentonite component facing down (Fig 14). In this case, a synthetic/ clay composite system is deployed in one single step. The material can be held in anchor trenches so that slope stability is assured, and can be either overlapped or heat seamed with Gundle's extrusion welder.



Possible Landfill Cap Sealing Systems Using Gundseal

(Fig 14)

GUNDSEAL MEMBRANE BACKING ALTERNATIVES

The product information sheet included in the Product Specification Section of this manual provides the properties for the 20 mil high density polyethylene liner that usually forms the membrane backing in the fabrication of Gundseal. However, Gundseal can also be fabricated on thicker high density polyethylene sheets. In addition to high density polyethylene, Gundseal can also be fabricated on very low density polyethylene membrane. Textured versions of the HDPE Gundseal and the VLDPE Gundseal are also offered by Gundle Lining Systems. The minimum thickness for the smooth HDPE and VLDPE sheets is 20 mils. The minimum thickness for the textured HDPE or VLDPE sheets is 40 mils. Specifications for the various thicknesses and textures available for Gundseal are provided in this section.

GUNDLINE® HD is a high quality formulation of High Density Polyethylene containing approximately 97.5% polymer and 2.5% of carbon black, anti-oxidants and heat stabilizers. The product was designed specifically for exposed conditions. It contains no additives or fillers which can leach out and cause embrittlement over time.

GUNDLINE® HD SPECIFICATIONS

TYPICAL PROPERTIES*	TEST METHOD	GAUGE (NOMINAL)							
		30 mil (0.75 mm)	40 mil (1.0 mm)	50 mil (1.25 mm)	60 mil (1.5 mm)	80 mil (2.0 mm)	100 mil (2.5 mm)	120 mil (3.0 mm)	140 mil (3.5 mm)
Density. g/cc. (Min.)	ASTM D1505	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Melt Flow Index. g/10 min. (Max.)	ASTM D1238 Condition E (190°C, 2.16 kg.)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Tensile Properties (Typical)	ASTM D 638 Type IV Dumb-bell at 2 ipm.								
1. Tensile Strength at Break (Pounds/inch width)		120	160	200	240	320	400	480	560
2. Tensile Strength at Yield (Pounds/inch width)		70	95	115	140	190	240	290	340
3. Elongation at Break (Percent)		700	700	700	700	700	700	700	700
4. Elongation at Yield (Percent)		13	13	13	13	13	13	13	13
Tear Resistance Initiation. lbs. (Typical)	ASTM D1004 Die C	22	30	37	45	55	65	80	95
Low Temperature Brittleness. °F (Typical)	ASTM D746 Procedure B	−112	−112	−112	−112	−112	−112	−112	−112
Dimensional Stability. % Change Each direction. (Max.)	ASTM D1204 212°F 1 hr.	±2	±2	±2	±2	±2	±2	±2	±2
Resistance to Soil Burial. Percent change in original value. (Typical)	ASTM D3083 using ASTM D638 Type IV Dumb-bell at 2 ipm.								
Tensile Strength at Break and Yield	% Change	±10	±10	±10	±10	±10	±10	±10	±10
Elongation at Break and Yield	% Change	±10	±10	±10	±10	±10	±10	±10	±10
Environmental Stress Crack. Hours. (Min.)	ASTM D1693 (10% Igepal, 50°C)	1500	1500	1500	1500	1500	1500	1500	1500
Puncture Resistance. Pounds. (Typical)	FTMS 101 Method 2065	30	52	65	80	105	130	150	169
Coefficient of Linear Thermal Expansion. $\times 10^{-4}$ $\frac{cm}{cm\ °C}$ (Typical)	ASTM D696	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Thermal Stability Oxidative Induction Time (OIT). Minutes. (Min.)	ASTM D3895 130°C, 800 psi O_2	2000	2000	2000	2000	2000	2000	2000	2000

**Note: All values except when specified as minimum or maximum are typical test results.*

PRODUCT DESCRIPTION

JOINING SYSTEMS

Critical to the success of any flexible membrane liner is the joining system. Gundle's Hot-Wedge Welding System and patented Extrusion Welding System are used to join individual panels of GUNDLINE HD. Request your copy of the Gundle Joining Systems Bulletin for complete details.

CHEMICAL RESISTANCE

GUNDLINE HD is resistant to a wide range of chemicals including acids, alkalis, salts, alcohols, amines, oils, and other hydrocarbons. Since combinations of chemicals of different concentrations and temperatures have different characteristics, consult Gundle for specific application details. Write for Gundle's chemical compatibility information.

SUPPLY SPECIFICATIONS

The following describes typical roll dimensions for GUNDLINE HD.

THICKNESS		WIDTH		LENGTH		AREA		ROLL WEIGHT	
mil	mm	ft	m	ft	m	ft^2	m^2	lb	kg
30	0.75	22.5	6.86	840	256	18,900	1756	2800	1272
40	1.0	22.5	6.86	650	198	14,625	1359	2800	1272
50	1.25	22.5	6.86	500	152	11,250	1043	2800	1272
60	1.5	22.5	6.86	420	128	9,450	878	2800	1272
80	2.0	22.5	6.86	320	98	7,200	670	2800	1272
100	2.5	22.5	6.86	250	76	5,625	522	2800	1272
120	3.0	22.5	6.86	210	64	4,725	439	2800	1272
140	3.5	22.5	6.86	180	55	4,050	377	2800	1272

THICKNESS		WIDTH		LENGTH		AREA		ROLL WEIGHT	
mil	mm	ft	m	ft	m	ft^2	m^2	lb	kg
30	0.75	34.5	10.5	840	256	28,980	2688	4400	2000
40	1.0	34.5	10.5	650	198	22,425	2079	4400	2000
50	1.25	34.5	10.5	500	152	17,250	1596	4400	2000
60	1.5	34.5	10.5	420	128	14,490	1344	4400	2000
80	2.0	34.5	10.5	320	98	11,040	1029	4400	2000
100	2.5	34.5	10.5	250	76	8,625	798	4400	2000

Gundle Lining Systems Inc

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GUNDLINE HD is rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Custom lengths available on request.

Printed in the U.S.A.

Gundline® VL (VLDPE) Lining System.

Now, there's a proven, cost-effective solution to flexibility requirements in many of your liner applications ... Gundle's Gundline® VL Very Low Density Polyethylene Liner (VLDPE). This high-performance polyolefin (also known as "FLEXOMER") has exceptional elastic properties. So, in applications such as landfill caps, tunnel lining, and potable water containment, where flexibility and elongation are more important than

chemical resistance, Gundline VL is ideal. Gundline VL also offers many of the traditional advantages of Gundline® HD liner such as UV light stability; low temperature resistance; microorganism, insect, and rodent resistance; 22.5-foot or 34.5 foot seamless widths and effective heat-seaming techniques.

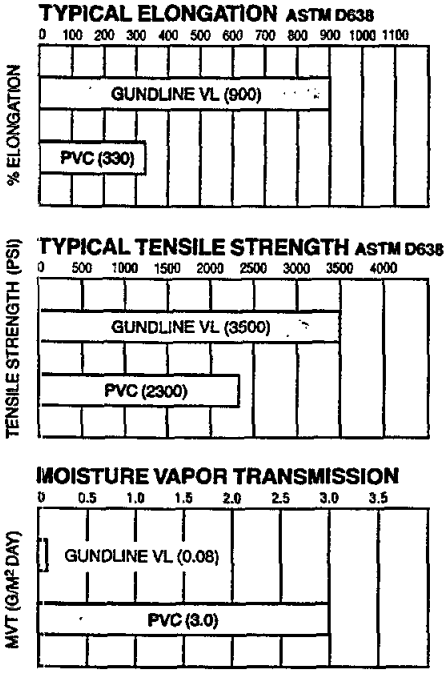
The Alternative Choice for Landfill Caps and Closures

Landfill cap design usually presents unique problems, especially potential differential settlement of the landfill. Gundline VL, with its excellent multiaxial elongation, offers tremendous insurance against problems due to settling. Clay liners, on the other hand, are known to lose much of their barrier properties due to the absence of elasticity, difficulties of proper compaction, weathering, and root growth.

Not only does the lining have excellent elasticity, but Gundline VL also offers excellent barrier properties to rainwater from outside the landfill while acting as a collector of gas from inside the landfill. Because of its flexibility, Gundline VL conforms very well to non-uniform surfaces. It "hugs" these surfaces tightly, providing good slope stability and puncture resistance over the closures.

A Gundline VL cap also promotes good vegetative growth in the top-soil cover of the closure by blocking the seepage of landfill gas through the vegetation. This enhances slope stability even further and provides better erosion control for the final closure.

Gundline® VL Liner Compared to PVC.



Polyvinyl Chloride (PVC) has been used in applications where flexibility is more important than chemical resistance. But the material achieves its flexibility from the addition of plasticizers. Present in PVC liners at 30% weight or more, plasticizers are low molecular-weight compounds such as monomeric fats.

These low molecular-weight additives can leach out because of heat, soil chemicals, and stresses in the liner, causing the liner to become brittle later on. Plasticizers are also food for rodents and microorganisms.

Gundline VL, on the other hand, contains no plasticizers. It achieves all of its flexibility and elongation from its inherent polymer structure. The natural strength and durability of polyethylene is combined with exceptional flexibility and elongation in Gundline VL. Gundle's co-extrusion technology can manufacture Gundline VL in one color or in layers of different colors. So go with Gundle's Gundline VL and stay with the leader.

GUNDLINE® VL (VLDPE) SPECIFICATIONS

Gundline VL is a special formulation of very low density polyethylene containing approximately 97.5% polymer and 2.5% carbon black, anti-oxidants and heat stabilizers.

TYPICAL PROPERTIES*	TEST METHOD	GAUGE (NOMINAL)					
		20 mil (0.5 mm)	30 mil (0.75 mm)	40 mil (1.0 mm)	60 mil (1.5 mm)	80 mil (2.0 mm)	100 mil (2.5 mm)
Tensile Properties. (Typical)							
1. Tensile Strength at Break (Pounds/inch width)	ASTM D638 Type IV Dumb-bell at 2 ipm, 2 inch gauge length, 2.5 inch grip separation	70	105	140	210	280	350
2. Elongation at Break (Percent)		900	900	900	900	900	900
Puncture Resistance. Pounds. (Typical)	FTMS 101 Method 2065	38	51	64	72	80	88
Tear Resistance Initiation. Pounds. (Typical)	ASTM D1004 Die C	8	12	16	24	32	40
Dimensional Stability. % Change. Each Direction. (Max.)	ASTM D1204 212°F 1 hr.	±2	±2	±2	±2	±2	±2
Low Temperature Brittleness. °F (Typical)	ASTM D746M Procedure B	−112	−112	−112	−112	−112	−112
Resistance to Soil Burial. Percent change in original value. (Typical)	ASTM D3083 Type IV Dumb-bell at 2 ipm						
Tensile Strength at Break.		±10	±10	±10	±10	±10	±10
Environmental Stress crack. Hours. (Min.)	ASTM D1693 10% Igepal, 50°C	1500	1500	1500	1500	1500	1500

*Note: All values, except when specified as minimum or maximum, are typical test results.

SUPPLY SPECIFICATIONS

The following describes typical roll dimension for Gundline VL

THICKNESS		WIDTH		LENGTH		AREA		ROLL WEIGHT	
mil	mm	ft.	m	ft.	m	ft.²	m²	lb.	kg.
20	0.5	22.5	6.86	1250	381	28,125	2613	2800	1272
30	0.75	22.5	6.86	840	256	18,900	1756	2800	1272
40	1.0	22.5	6.86	650	198	14,625	1359	2800	1272
60	1.5	22.5	6.86	420	128	9,450	878	2800	1272
80	2.0	22.5	6.86	320	98	7,200	670	2800	1272
100	2.5	22.5	6.86	250	76	5,625	522	2800	1272

GUNDLINE VL is rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Custom lengths available upon request.

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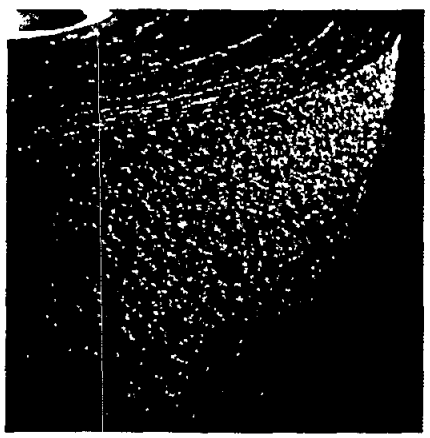
These specifications are offered as a guide for consideration to assist engineers with their specifications; however, Gundle assumes no liability in connection with the use of this information. The specifications on this data sheet are subject to change without notice.

Textured Gundline® HDT Maximizes Slope Stability

Gundle Lining Systems has developed a method for adding a rough texture to the surface of our durable High Density Polyethylene (HDPE) liners. The result is a high performance product called Gundline HDT which increases slope stability in engineered landfills and other lining applications.

Gundline HDT's special textured surface dramatically improves slope stability by increasing friction between the synthetic liner and soils, geotextiles, and other geosynthetics. Cover soils are held on the liner with the greatly increased friction, and safety-conscious engineers can improve factors of safety on slopes of varying steepness. Table 1 lists the improvements in friction angle for Gundline HDT, determined by direct shear box testing.



The innovative friction surface of Gundline HDT is manufactured simultaneously with extrusion of the solid barrier portion of the liner as opposed to being added after extrusion. It's a rough surface, fully integrated with the sheet during the molten phase of manufacture. As a result, it has excellent abrasion resistance and remains intact regardless of chemicals contacting the sheet surface.

Textured Gundline® VLT

Gundline VLT combines the exceptional elongation and elastic properties of Gundline® VL (Very Low Density Polyethylene Liner) with a textured surface to offer the outstanding friction characteristics and slope stabilizing qualities of Gundline® HDT! The combination makes the liner ideal for landfill closures and other applications where elongation, flexibility, and slope stability are important. The excellent multi-axial elongation of Gundline VLT accommodates differential settlement while the textured surface provides long term slope stability.

	FRICTION ANGLE (DEGREES)	
SLIDING SURFACE	POLYETHYLENE	TEXTURED
Gundline/H.R. Clay	16	24
Gundline/Ottawa Sand	17	26
Gundline/Geotextile (Nonwoven)	11	29

*Note: Friction angles for the products listed are typical only and may vary with local soil conditions. Accordingly, engineers must test friction angles for the product using site specific soil composition for all designs incorporating the product.

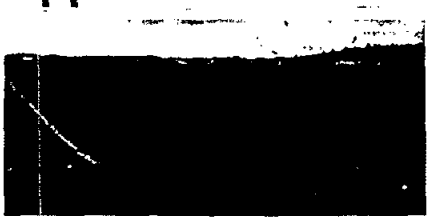
Gundline HDT Retains The Important Advantages Of Gundline® HD.

Manufactured in 22.5 foot wide seamless rolls and in thicknesses ranging from 40-100 mils of barrier wall, Gundline HDT features the same important qualities that have made Gundline HD the world's leading lining system. Tensile strength before yielding, biaxial elongation, tear resistance, puncture resistance, ultraviolet light resistance, chemical resistance, dimensional stability, heat resistance, and stress crack resistance are all excellent. So is resistance to microorganisms and rodent damage.

As with Gundline HD, Gundle manufactures Gundline HDT with only the top performing pipe grade HDPE resin. The superior high grade resin creates an ideal structure to the finished sheet.

HDPE resin and carbon black concentrate used in manufacturing.

Gundline HDT Provides Solutions To Difficult Applications.



A recent problem at Islip, New York illustrates the effectiveness of Gundline HDT. It began when the city's municipal landfill neared capacity. The problem was then compounded by the lack of available land for expansion. But Gundle provided the solution. After considering all available options, it was decided to expand vertically—a process dubbed "piggybacking." A new cell would be created to sit atop the existing closed and capped landfill. However, it was critical to establish slope stability for the new, steep slopes of this 80-foot high addition. So Gundle manufactured and installed 1.2 million square feet of Gundline HDT and successfully increased the friction angle between the liner and the sand over sixty percent.

Today, not only does Islip have 1.8 million cubic yards of new refuse disposal capacity, but they also have peace of mind knowing it's lined with the industry's most stable and durable liner.

GUNDLINE® HDT SHEET SPECIFICATIONS

TYPICAL PROPERTIES*	TEST METHOD	GAUGE (NOMINAL)			
		40 mil (1.0 mm)	60 mil (1.5 mm)	80 mil (2.0 mm)	100 mil (2.5)
Tensile Properties (Typical)	ASTM D638 Type IV Dumb-bell at 2 ipm, 2 inch gauge length, 2.5 inch grip separation				
1. Tensile Strength at Break (Pounds/inch width)		23	35	46	56
2. Tensile Strength at Yield (Pounds/inch width)		84	126	168	210
3. Elongation at Break (Percent)		100	100	100	100
4. Elongation at Yield (Percent)		13	13	13	13
Tear Resistance Initiation. Pounds. (Typical)	ASTM D1004 Die C	30	45	60	75
Puncture Resistance. Pounds. (Typical)	FTMS 101 Method 2065	45	70	95	110

*(*Note: All values are typical test results.)*

SUPPLY SPECIFICATIONS

The following describes typical roll dimensions for Gundline HDT

NOMINAL THICKNESS		WIDTH		LENGTH		AREA		ROLL WEIGHT	
mil	mm	ft.	m	ft.	m	ft.²	m²	lb.	kg.
40	1.0	22.5	6.86	500	152	11,250	1045	2780	1261
60	1.5	22.5	6.86	420	128	9,450	878	3270	1483
80	2.0	22.5	6.86	320	97	7,200	669	3200	1452
100	2.5	22.5	6.86	250	76	5,625	522	3056	1386

GUNDLINE® VLT SHEET SPECIFICATIONS

TYPICAL PROPERTIES*	TEST METHOD	GAUGE (NOMINAL)			
		30 mil (.75mm)	40 mil (1.0 mm)	60 mil (1.5 mm)	80 mil (2.0 mm)
Tensile Properties (Typical)	ASTM D638 Type IV Dumb-bell at 2 ipm.				
1. Tensile Strength at Break (Pounds/inch width)		45	55	70	85
2. Elongation at Break (Percent)		300	300	300	300
Tear Resistance Initiation Pounds. (Typical)	ASTM D1004 Die C	12	16	24	30
Puncture Resistance Pounds. (Typical)	FTMS 101 Method 2065	26	38	57	70
Multi-Axial Elongation	GR1-GM4	75	75	75	75

*(*Note: All values are typical test results.)*

SUPPLY SPECIFICATIONS

The following describes typical roll dimensions for Gundline VLT

NOMINAL THICKNESS*		WIDTH		LENGTH		AREA		ROLL WEIGHT	
mil	mm	ft.	m	ft.	m	ft.²	m²	lb.	kg.
30	0.75	22.5	6.86	840	256	18,900	1756	2141	971
40	1.0	22.5	6.86	500	152	11,250	1045	2676	1214
60	1.5	22.5	6.86	420	128	9,450	878	3147	1427
80	2.0	22.5	6.86	320	97	7,200	669	3083	1398

GUNDLINE HDT and GUNDLINE VLT are rolled on 6" I.D. hollow cores. Each roll is provided with 2 slings to aid handling on site. Dimensions and weights are approximate. Custom lengths available upon request.

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These specifications are to be used only as a general guideline for use by engineers in formulating preliminary specifications, and should not be relied upon absent site-specific product testing; and Gundle assumes no responsibility for the improper reliance upon or misuse of such data. In addition, product design and specifications are subject to change without notice.

AR313150

TECHNICAL REVIEW OF
BENTONITE COATINGS

A. Formation

In the earth's past, the raw power of nature relentlessly shaped the planet with violent volcanic eruptions splitting the earth's crust. Molten lava poured across the land and tons of hot ash and gas spewed into the atmosphere.

This ash gradually settled to the earth's surface. In some instances, the ash settled into shallow, salt water seas. Tectonic activity uplifted an area now called the Black Hills. Weathering of this ash produced a high swelling clay that is commercially mined for its unique properties.[1]

This special clay outcrops near Ft. Benton, Wyoming and was first studied in 1896. "Bentonite" is available in economically recoverable quantities, in Wyoming and to a lesser extent in South Dakota and Montana. Wyoming bentonite is typically composed of sodium montmorillonite, feldspar, quartz, and calcite. Bentonite's unique properties are provided by the principle constituent, sodium montmorillonite. The highest quality bentonites contain high percentages of sodium montmorillonite. The most significant characteristics of sodium montmorillonite are:

- o An ability to expand and contract as water is absorbed and expelled
- o This expansion and contraction can occur an infinite number of times
- o An ability to swell 10 to 20 times its original volume
- o An ability to absorb up to five times its weight in water
- o Since it is totally inorganic, it does not break down with time, and
- o In thicknesses of 3/16 to 3/8 inch, it has a hydraulic conductivity of 1×10^{-10} centimeters per second (cps).

These characteristics are unique to high grade sodium bentonites and cannot be obtained by calcium bentonites or "beneficiated" calcium bentonites.

B. Chemical Composition

Compositionally sodium montmorillonite is mostly SiO_2. The critical components to quality montmorillonite are percent sodium oxide (Na_2O), Lime (CaO), and water (H_2O). The most active, thereby highest quality, montmorillonites are:

- o Greater than 2.0% Na_2O
- o Less than 1.0% CaO
- 0 Five to 10% water (processed material)

Typical chemical composition of the bentonite is provided below:

Mineral	Percent
Silicon Dioxide (SiO_2)	63
Aluminum Oxide (Al_2O_3)	18
Ferric Oxide (Fe_2O_3)	3
Sodium Oxide (Na_2O)	2
Magnesium Oxide (MgO)	2
Lime (CaO)	1
Miscellaneous	1-5
Water Content (processed material)	5-10 percent

C. Reaction With Polar Fluids

Individual clay platelets are flat, about 100-500 times larger in width and length as compared to thickness. One cubic inch of bentonite clay contains almost 10 trillion individual platelets. Laid side by side, these platelets will have a total surface area of about one square acre. Imagine a one-inch square sheet of paper; this small piece of paper would represent a bentonite flake magnified 400 times.

Researchers have extensively studied the molecular structure of bentonite clays. The crystal structure of montmorillonite is illustrated in Figure 1. The montmorillonite plates consist of three layer units arranged randomly above one another in loosely aggregated stacks. Each tetrahedron consists of four oxygen atoms surrounding a silicon atom. Each octahedron consists of six hydroxyls usually surrounding an aluminum atom (called a gibbsite sheet) or occasionally a magnesium atom (called a brucite sheet). For each three layer unit, one aluminum (or magnesium) octahedral sheet is sandwiched between two silicate tetrahedral sheet.[2]

By virtue of their formation, via a process called "isomorphous substitution", all clay minerals carry a net negative charge on their surface. The surface activity for montmorillonite measures as 360 to 500 x 10^{20} (number of positive charges adsorbed per 100 gm soil).

It is this tremendous quantity of negative charges that causes the unique reaction of sodium bentonite with water. The hydration of clay particles with water involves at least three different mechanisms:[2]

1. Dipole water effects occur because the water molecule is unbalanced in a positive-negative sense. Therefore, the positive (hydrogen) side of the water molecule will be attracted to the negatively charged surfaces of the clay particles. This very strong attraction can extend for many molecules away from the surface of the clay and into the saturated voids of the soil.

2. Nonhydrated cations in the void liquid will also be attracted to the negatively charged surfaces of the clay. They will interact in a very complex manner with respect to the water dipoles, both of which compete for their optional position against the clay particle surfaces.

3. Direct hydrogen bonding of water to oxygen atoms on the clay's surface is also likely to occur.

These three mechanisms combine to form the diffuse double layer which is immediately adjacent to the surface of the clay particles and extends out into the void space between particles. This layer, the "adsorbed layer", gives clay soils their plasticity characteristics as evidenced by both a cohesive strength and a relatively low hydraulic conductivity (permeability). This low permeability is of great interest in clay liner technology. The lowest permeabilities occur with montmorillonite clays which have the highest surface activity, hence the thickest adsorbed water layer. This adsorbed water layer leaves little remaining void space for the flow of free water, hence low values of hydraulic conductivity. This reaction of sodium bentonite with water is illustrated in Figures 1 thru 4.

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[1]Shan, H. Y., Laboratory Tests on a Bentonite Blanket, (MSCE Thesis, Univeristy of Texas at Austin), May 1990

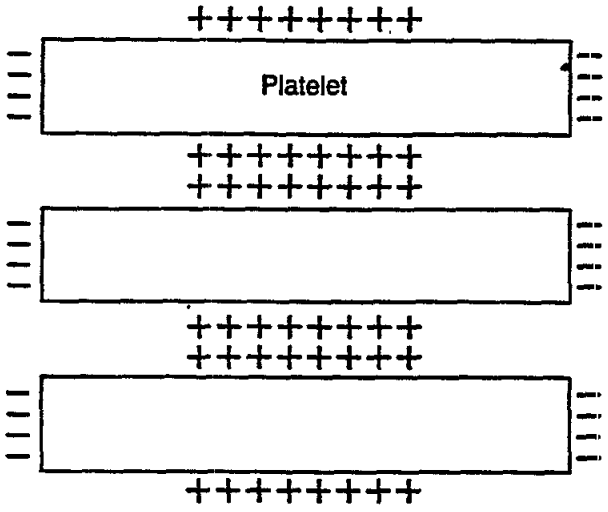
[2]Eith, A. W., Boschuck, J., and Koerner, R. M., Prefabricated Bentonite Clay Liners, Proceedings, 4th GRI Seminar, Landfill Closures: Geosynthetics, Interface Friction and New Developments (Geosynthetic Research Institute, Drexel University, 1990)

[3]Bohn, H., McNeal, B., and O'Connor, G., Soil Chemistry, 2nd edition (John Wiley & Sons, New York, 1985), pp. 341

HOW BENTONITE REACTS WITH WATER

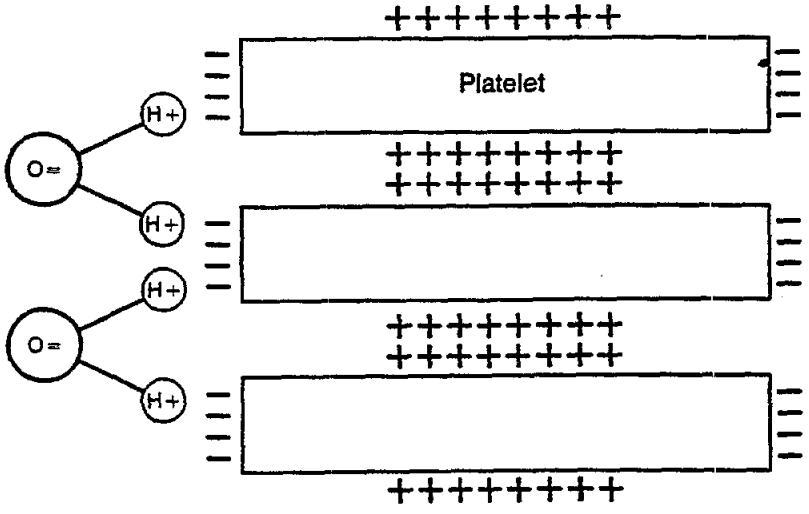
1. BENTONITE PLATELETS

Bentonite consists of platelets that have a strong negative (-) charge on the ends and strong positive (+) charge in the center. The platelets resemble a set of stacked dishes.



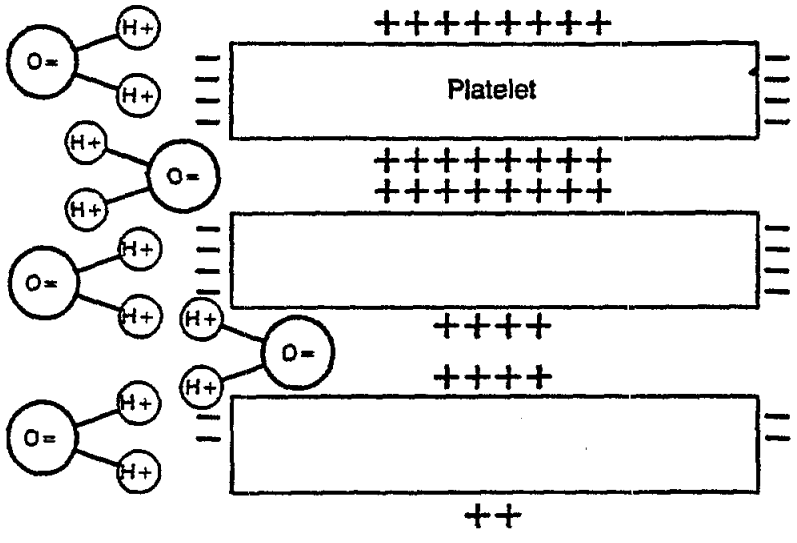
2. PLATELETS IN CONTACT WITH WATER

When water comes in contact with Bentonite, its positive hydrogen atom (H+) seeks negative charges (-) on the surface of the clay platelets.



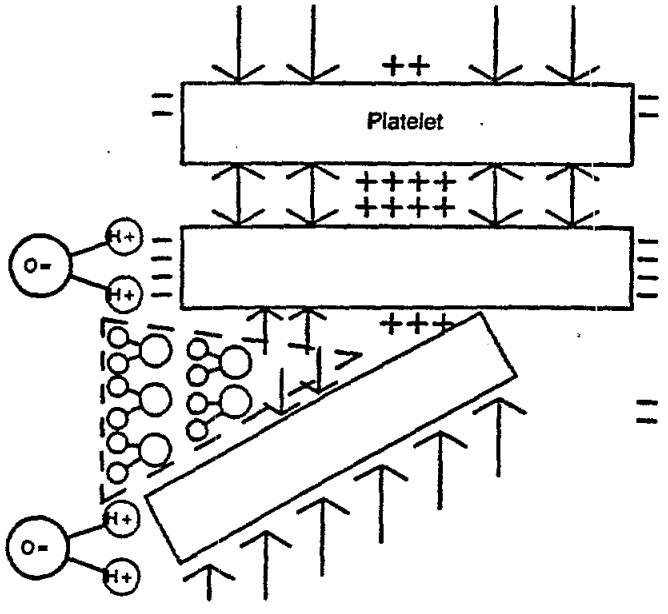
3. NEUTRALIZATION OF BENTONITE PLATELETS

As the negative charges at the ends of the platelets become neutralized, the remaining negative oxygen atoms in the free water are attracted to the positive charges in the middle of the platelet. At this point some water molecules enter the platelets, and in so doing, force them to spread apart (swell and gel).



4. WATER ENTERING PLATELETS

A wedge of large water molecules enters and separates (gelling action) the platelets. Note: As long as the platelets are in compression, they can only spread a limited distance and, therefore, trap or jam the water molecules as they try to enter. Once this state has been reached, the bentonite platelets are truly waterproof.



APPENDIX 12
FORM D
AREAS WHERE CLASS I RESIDUAL WASTE LANDFILLS ARE PROHIBITED

From:
Commonwealth of Pennsylvania
Department of Environmental Resources
Bureau of Waste Management

Date Prepared/Revised

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF WASTE MANAGEMENT

I.D. Number

FORM D - RESIDUAL EXCLUSIONARY AREA CRITERIA / ENVIRONMENTAL ASSESSMENT PROCESS FOR RESIDUAL WASTE MANAGEMENT FACILITIES

INSTRUCTIONS

Permit applicants must subject lands proposed for processing or disposal of residual waste to the standards set forth in the regulations governing same prior to issuance of a waste management permit.

Form D is to be completed and submitted to the Department as a component of a permit application. If a permit application is submitted in Phases, this form must be submitted with Phase I.

Section One contains absolute and mitigable exclusionary area criteria -- if an affirmative response is given, additional information may be required. If the Department determines that the additional information does not mitigate the concerns, then the permit application will be denied for the proposed area.

Section Two allows the Department to evaluate the applicant's environmental assessment to determine whether the proposed operation has the potential to cause environmental harm. If the applicant determines that the proposed operation may cause environmental harm, the applicant must provide a written explanation of how it plans to mitigate the potential harm. The assessment may include a description of the social and economic benefits of the project.

Applicants should answer each question that applies to the type of facility they intend to operate, and provide the required additional information for all affirmative responses. Attachments may be necessary if additional information is required. The Department may require information in addition to that provided in this form, if it deems necessary. In addition, a USGS 7.5 minute topographic quadrangle map, indicating the perimeter of the permit area (to approximate scale) and all environmental impact areas (as indicated by this form) shall be attached.

When locating a permit area with respect to the boundaries of environmental impact areas identified by this form, applicants should be aware that distances from a facility to a feature or structure (described by these standards) shall be measured from the ***perimeter*** of the proposed permit area. Permit area is defined as "The area of land and water within the boundaries of the permit which is designated on the permit application maps as approved by the Department. The term includes the areas which are or will be affected by the residual waste processing or disposal facility." (reference § 287.1)

I.D. Number

FORM D

APPLICABILITY

The Exclusionary Area Criteria apply to the siting of all residual waste processing and disposal facilities requiring permits under the law. However, the regulations provide the following exceptions to the applicability of the Environmental Assessment Process (Section Two) unless the Department determines that the facility may have significant effect on the environment:

1. Agricultural Utilization of Residual Waste Facilities.
2. Land Reclamation facilities for Residual Waste.
3. Permit modification applications that are not considered to be "major" modification as indicated by the regulations (reference §287.159).

For facilities which were subjected to the Environmental Assessment Process prior to July 4, 1992, the Department will ***limit*** the scope of review to the following:

1. Proposed modifications to the facility.
2. Changes (in the area covered by the assessment) that have occurred since the last assessment was conducted.

I.D. Number

FORM D

SECTION ONE - EXCLUSIONARY AREA CRITERIA

A. If the facility is a Residual Waste Landfill or Disposal Impoundment, answer the following about the facility's location:

Regulatory Citation		Yes	No	
§288.422 §288.522 §288.622 §289.422 §289.522	1.	☐	☒	Is it within the 100-year floodplain of any waters of the Commonwealth? Attach floodplain map showing facility location.
	2.	☐	☒	Is it within 300 feet of an exceptional value wetland?
	3.	☐	☒	Is it within 100 feet of a wetland other than an exceptional value wetland?
				If yes, complete following:
		☐	☐	a. Will storage, processing, or disposal occur within 100 feet of the wetland?
				b. Check one of the following if applicable:
		☐	☐	A chapter 105 permit has been obtained.
		☐	☐	No adverse hydrologic or water quality impacts will result. Attach explanation.
	4.	☐	☒	Is it located in coal bearing areas underlain by recoverable or mineable coals?
		☐	☐	If yes, does the applicant own the underlying coal? If so, attach documentation.
	5.	☐	☒	Is it located in a valley, ravine, or head of hollow where the operation would result in the elimination, pollution, or destruction of a portion of a perennial stream?
		☐	☐	If yes, and rechanneling is proposed, has a permit been applied for under Chapter 105? Explain.
	6.	☐	☒	Is it located in an area underlain by limestone or carbonate formations where the formations are greater than five feet in thickness and present at the topmost geologic unit?
		☐	☒	Is it located in an area mapped by the PA Geological Survey as underlain by these formations?
		☐	☐	If included in the area mapped, are geologic studies available to demonstrate the absence of sinkhole development and sinkhole-prone limestone and carbonate formations? Provide documentation.

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	Yes	No	
7a.	☐	☒	For facilities not permitted before July 4, 1992, is the facility located within 300 feet measured horizontally from an occupied dwelling?
	☐	☐	If yes, has the current owner provided a written waiver consenting to the facility being closer than 300 feet? Attach a copy of written consent.
7b.	☐ N/A	☐	If the facility was permitted prior to July 4, 1992, is the disposal area for the residual waste landfill located within 500 feet measured horizontally from an occupied dwelling?
	☐	☐	If yes, has the current owner provided a written waiver consenting to the disposal area being closer than 500 feet? Attach a copy of written consent.
8.	☐	☒	Within 100 feet of a perennial stream?
			If yes, answer the following:
	☐	☐	a. Will storage, processing, or disposal activities occur within that distance?
	☐	☐	b. Will any adverse hydrologic or water quality impacts result? attach explanation.
9.	☐	☒	Within 100 feet of a property line?
			If yes, check the following if applicable:
	☐	☐	a. Actual disposal will not occur within that distance.
	☐	☐	b. The current owner has provided a written consent to the facility being closer that 100 feet. Attach a copy of written consent.
10.	☐	☒	Within 25 feet of a coal seam, coal outcrop, or coal refuse?
	☐	☐	If yes, is the waste noncombustible? Attach explanation.
11.	☐	☒	a. Is the facility's processing, disposal, or storage areas located within 1/4 mile upgradient of a private or public water source?
	☐	☒	b. Is the facility's processing, disposal, or storage areas located within 300 feet downgradient of a private or public water source?

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FORM D

	Yes	No	
			If yes to either of the above, answer the following:
	☐	☐	a. Have the owners of the public and private water source in the isolation area consented, in writing, to the location of the proposed facility? Attach written consent.
	☐	☐	b. Have the operator and each owner agreed, in writing, that the applicant will construct and maintain, at the operators expense, a permanent alternative water supply, of like quantity and quality, at no additional cost to the water source owner, if the existing source is adversely affected by the facility? Provide documentation.
	☐	☐	c. Has applicant has demonstrated that a replacement water source is technically and economically feasible and readily available for every public or private water source in the isolation area? Provide documentation.
12.	☐	☒	Does the facility receive or propose to receive putrescible waste?
			If yes, answer the following
	☐	☐	a. Is it located within 10,000 feet -- or 3,048 meters -- of an airport runway that is or will be used by turbine-powered aircraft during the life of the disposal operations under the permit?
	☐	☐	b. Is it located within 5,00 feet -- or 1,524 meters -- of an airport runway that is or will be used by piston type aircraft during the life of the disposal operations under the permit?

B. If the facility is a Transfer Facility, Incinerator, or other Processing Facility, answer the following about the facility's location:

§297.202 §293.202	1.	☐	☐	Is it within the 100-year floodplain of any waters of the Commonwealth? Attach floodplain map showing facility location.
N/A	2.	☐	☐	Is it within 300 feet of an exceptional value wetland?
	3.	☐	☐	Is it within 100 feet of a wetland other than an exceptional value wetland?
				If yes, complete following:
		☐	☐	a. Will storage, processing, or disposal occur within 100 feet of the wetland?

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N/A

	Yes	No	
			b. Check one of the following if applicable:
	☐	☐	A chapter 105 permit has been obtained.
	☐	☐	No adverse hydrologic or water quality impacts will result. Attach explanation.
4.	☐	☐	Is it within 300 feet, measured horizontally, from an occupied dwelling?
	☐	☐	If yes, has the owner of the dwelling provided a written waiver consenting to the facility being closer than 300 feet? Attach a copy of written consent.
5a.	☐	☐	For Transfer Facilities, is the facility located within 100 feet of a perennial stream?
			If yes, answer the following:
	☐	☐	a. Will actual storage and disposal occur within that distance?
	☐	☐	b. Will any adverse hydrologic or water quality impacts result? Attach explanation.
5b.	☐	☐	For Incinerators and other Processing Facilities, is the facility located within 100 feet of a perennial or intermittent stream?
			If yes, answer the following:
	☐	☐	a. Will actual storage and disposal occur within that distance?
	☐	☐	b. Will any adverse hydrologic or water quality impacts will result? Attach explanation.
6a.	☐	☐	For transfer facilities, is the location within 50 feet of a property line?
	☐	☐	Is yes, will actual processing occur within that distance?
6b.	☐	☐	For incinerators and other Processing Facilities, is the location within 50 feet of a property line?
			If yes, check one or more of the following if applicable:
	☐	☐	Actual processing of waste will not occur within that distance.
	☐	☐	All owners of occupied dwellings within that distance have provided written waivers consenting to the facility being closer than 50 feet? Attach a copy of written consent.

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N/A

	Yes	No	
7.	☐	☐	For commercial Incinerators and other commercial Processing Facilities permitted after September 26, 1988, is the facility located within 300 yards of the following:
	☐	☐	a. A building which is owned by a school district or parochial school and used for instructional purposes.
	☐	☐	b. A park existing prior to the date the Department receives an administratively complete application for a permit for such facility.
	☐	☐	c. A playground existing prior to the date the Department receives an administratively complete application for a permit for such facility.

C. If the facility is a Composting Facility, answer the following about the facility's location:

§295.202

1.	☐	☐	Is it within the 100-year floodplain of any waters of the Commonwealth? Attach floodplain map showing facility location.
2.	☐	☐	Is it within 300 feet of an exceptional value wetland?
3.	☐	☐	Is it within 100 feet of a wetland other than an exceptional value wetland?
			If yes, complete following:
	☐	☐	a. Will storage, processing, or disposal occur within 100 feet of the wetland?
			b. Check one of the following if applicable:
	☐	☐	A chapter 105 permit has been obtained.
	☐	☐	No adverse hydrologic or water quality impacts will result. Attach explanation.
4.	☐	☐	Within 100 feet of a sinkhole or area draining into a sinkhole?
5.	☐	☐	Within 300 feet, measured horizontally, from an occupied dwelling?
	☐	☐	If yes, has the owner of the dwelling provided a written waiver consenting to the facility being closer than 300 feet? Attach a copy of written consent.

N/A

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	Yes	No	
6.	☐	☐	Within 100 feet of a perennial stream?
			If yes, answer the following:
	☐	☐	a. Will actual storage, processing, and disposal occur within that distance?
N/A	☐	☐	b. Will any adverse hydrologic or water quality impacts result? Attach explanation.
7.	☐	☐	Within 50 feet of a property line?
	☐	☐	If yes, does the actual composting of waste occur within that distance? Provide explanation.
8.	☐	☐	a. Within 1/4 mile upgradient of a private or public water source?
	☐	☐	b. Within 300 feet downgradient of a private or public water source?
	☐	☐	If yes to either of the above, will processing, disposal, and waste or compost storage occur within this distance?
9.	☐	☐	In an area where the seasonal high water table or perched water table is less than 4 feet from the surface?

D. If the facility is a Land Application Facility for Residual Waste, answer the following about the facility's location:

§291.202	1.	☐	☐	Within 100 feet of an intermittent stream or perennial stream?.
	2.	☐	☐	Within 300 feet of a water source, unless otherwise approved by the Department, in writing? Attach explanation.
N/A	3.	☐	☐	Within 1,000 feet upgradient of a surface water source, unless otherwise approved by the Department, in writing? Attach explanation.
	4.	☐	☐	Within 25 feet of a bedrock outcrop?
	5.	☐	☐	Within 50 feet of a property line within which the residual waste is applied?
		☐	☐	If yes, has the owner provided a written consent to the land application being closer than 50 feet? Provide a copy of written consent.
	6.	☐	☐	Within 100 feet of a sinkhole or area draining into a sinkhole?

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		Yes	No	
	7.	☐	☐	Within 25 feet of the perimeter of an undrained depression?
N/A	8.	☐	☐	In or within 100 feet of an exceptional value wetland?
	9.	☐	☐	Within 300 feet, measured horizontally, from an occupied dwelling?
		☐	☐	If yes, has the owner of the dwelling provided a written waiver consenting to the facility being closer than 300 feet? Attach a copy of written consent.
	10.	☐	☐	For the surface land disposal of residual waste, is the location within the 100-year floodplain of any waters of the Commonwealth? Attach floodplain map showing facility location.

E. If you are applying for an expansion of a captive facility, complete the following:

§288.522
§288.622
§288.422

1. If you are requesting a waiver or modification for an isolation distance, check the following appropriate boxes below. Make sure to identify the proposed isolation distance in the space provided.

N/A

☐ a. Within the 100-year floodplain of the waters of the Commonwealth.

Proposed isolation distance:

☐ b. Within a valley, ravine, or head of hollow where the operation would result in the elimination, pollution, or destruction of a portion of a perennial stream.

☐ c. For disposal areas within 500 feet measured horizontally from an occupied dwelling.

Proposed isolation distance:

☐ d. Within 100 feet of a perennial stream.

Proposed isolation distance:

☐ e. For processing, disposal, and storage areas within 1/4 mile upgradient of a private or public water source.

Proposed isolation distance:

☐ f. For processing, disposal, and storage areas within 300 feet downgradient of a private or public water source.

Proposed isolation distance:

2. Demonstrate all of the following:

   a. The captive facility was permitted prior to July 4, 1992 or was permitted after July 4, 1992 if the Department determined the permit application to be administratively complete prior to January 21, 1992. Provide documentation.

   b. The captive facility routinely and regularly disposed of residual waste on and after July 4, 1992. Provide documentation.

N/A

   c. The expansion of the captive facility solely includes land which is contiguous to the captive facility. Provide documentation.

   d. The expansion of the captive facility solely includes land which is owned by the applicant on January 21, 1992.

   e. No other site is available on contiguous land for the expansion of the captive facility. Provide documentation.

   f. The expansion of the captive facility will be designed and operated to ensure that the facility does not harm public health, safety, welfare, or the environment. Provide documentation.

3. Does the applicant propose to expand the captive facility onto land which is closer to any occupied dwelling than the facility's location prior to the expansion? (Yes or No)

N/A

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FORM D

ECTION TWO - ENVIRONMENTAL ASSESSMENT CRITERIA:

Part One:

A. Provide a detailed analysis of the potential impact of the proposed facility on the environment, public health, and public safety including the following:

1. traffic
2. aesthetics
3. air quality
4. water quality
5. stream flow
6. fish and wildlife
7. plants
8. aquatic habitat
9. threatened or endangered species
10. water uses
11. land use

} SEE SECTION 3.1.1 ENVIRONMENTAL ASSESSMENT

B. In addition, please address the following questions.

An affirmative response to any of the following requires that the applicant completely address the additional questions set forth for that particular item. (The Department may require additional information, as deemed necessary).

	Yes	No	
1.	☒	☐	Is the project in the corridor of a stream or river designated as a national or state wild, scenic, recreational, or modified recreational river in accordance with the National Wild and Scenic Rivers Act of 1968, or the Pennsylvania Scenic Rivers Act?

If "yes,"

a. Identify the river, the outline of the designated corridor, and the location of the project within the corridor.

b. Describe how the project conforms to the Land Management Guidelines and Studies or Plans for the corridor.

SEE NARRATIVE IN SECTION 3.1.14.1

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FORM D

	Yes	No	
2.	☐	☒	Is the project located within one mile of the nearest bank of a stream or river listed as a 1-A priority for study by the Department of Environmental Resources as a state wild, scenic, recreational, or modified recreational river; or mandated by the U.S. Congress for study or determined by the U.S. Heritage Conservation and Recreation Service to meet the criteria for study for potential inclusion into the National Wild and Scenic Rivers System?

If "yes,"

a. Identify the river or stream and its distance from the project.

b. Conduct visual and traffic analyses as specified in the applicant guidelines.

c. Describe the characteristics of the project which might create adverse environmental, visual, or traffic impacts on or in the vicinity of the river or stream.

d. Describe measures to be taken to minimize adverse impacts on the river or stream.

3.	☐	☒	Is the project located within one mile of a unit of the National Parks System; a state, county, or municipal park; recreation facility operated by the U.S. Army Corps of Engineers; a state forest picnic area; or the Allegheny River Reservoir in the Allegheny National Forest?

If "yes,"

a. Identify the park or other area and its distance from the project.

b. Conduct visual and traffic analyses as specified in the applicant guidelines.

c. Describe the characteristics of the project which might create adverse environmental, visual, or traffic impacts on the park or other area.

d. Describe measures to be taken to minimize adverse impacts on the park or other area.

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	Yes	No	
4.	☐	☒	Is the project within one mile of the footpath of the Appalachian Trail?

If "yes,"

a. Indicate the distance from the project to the Appalachian Trail.

b. Conduct visual and traffic analyses as specified in the applicant guidelines.

c. Describe the characteristics of the project which might create adverse environmental, visual, or traffic impacts on the Appalachian Trail.

d. Describe measures to be taken to minimize adverse impacts on the Appalachian Trail.

5.	☐	☒	Is the project located within one mile of a national natural landmark designated by the U.S. National Park Service; or a natural area, or wild area designated by the Pennsylvania Environmental Quality Board.

If "yes,"

a. Identify the natural landmark, natural area, or wild area and its distance from the project.

b. Conduct visual and traffic analyses as specified in the applicant guidelines.

c. Describe the characteristics of the project which might create adverse environmental, visual, or traffic impacts on the natural landmark, natural area, or wild area.

d. Describe measures to be taken to minimize adverse impacts on the natural landmark, natural area, or wild area.

6.	☐	☒	Is the project located within one mile or within an identified potential impact area of a national wildlife refuge, national fish hatchery, or national environmental center operated by the U.S. Fish and Wildlife Service?

If "yes,"

a. Identify the wildlife refuge, fish hatchery, or environmental center and its distance from the project.

b. Conduct visual and traffic analyses as specified in the applicant guidelines.

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	Yes	No	
			c. Describe the characteristics of the project which might create adverse environmental, visual, or traffic impacts on the wildlife refuge, fish hatchery, or environmental center.
			d. Describe measures to be taken to minimize adverse impacts on the wildlife refuge, fish hatchery, or environmental center.
7.	☐	☒	Is the project located within one mile of an historic property owned by the Pennsylvania Historical and Museum Commission?
			If "yes,"
			a. Identify the historic property and its distance from the project.
			b. Conduct visual and traffic analyses as specified in the applicant guidelines.
			c. Describe the characteristics of the project which might create adverse environmental, visual, or traffic impacts on the historic property.
			d. Describe measures to be taken to minimize adverse impacts on the historic property.
8.	☐	☒	Is the project located within ¼ mile of an historic site listed in the National Register of Historic Places or the Pennsylvania Inventory of Historic Places; or an archaeological site listed in the Pennsylvania Archaeological Site Survey?
			If "yes,"
			a. Identify the historic or archaeological site, and its distance from the project.
			b. Describe the characteristics of the project which might create adverse impacts on the historic or archaeological site.
			c. Describe measures to be taken to minimize adverse impacts on the historic or archaeological site.
			d. Indicate any contact you have had with the Pennsylvania Historical and Museum Commission about the project.

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FORM D

	Yes	No	
9.	☐	☒	Is the project located within ¼ mile of the boundary of a state forest or state game land; or the proclamation boundary of the Allegheny Natural Forest?

If "yes,"

a. Identify the forest or game land and its distance from the project.

b. Describe the characteristics of the project which might create adverse impacts on the forest or game land.

c. Describe measures to be taken to minimize adverse impacts of the project on the forest or game land.

10.	☐	☒	Is the project located within an area which is a habitat of a rare, threatened, or endangered species of plant or animal protected by the Federal Endangered Species Act of 1973, or recognized by the Pennsylvania Department of Environmental Resources, Pennsylvania Fish Commission or Pennsylvania Game Commission?

If "yes,"

a. Identify the species and the habitat area and the location of the project within the area.

b. Describe the characteristics of the project which might create adverse impacts on the species or habitat.

c. Describe measures to be taken to minimize adverse impacts on the species or habitat.

d. Describe any contact you have had with the Pennsylvania Fish Commission, Pennsylvania Game Commission, Pennsylvania Historical and Museum Commission, U.S. Fish and Wildlife Service, or the Pennsylvania Department of Environmental Resources (Plant Program) about the project.

11.	☐	☒	Is the project located on prime farmland (Class I and II soils) as indicated in the U.S. Soil Conservation Service County Soil Survey?

If "yes,"

Identify the location and acreage of prime farmland and the location of the project.

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	Yes	No	
12.	☒	☐	Is the project located within a Special Protection Watershed, as designated in Chapter 93 (relating to Pennsylvania's Stream Water Quality Criteria) of the Rules and Regulations of the Pennsylvania Department of Environmental Resources?

SEE NARRATIVE IN SECTION 3.1.14.1

If "yes,"

a. Identify the stream and watershed, and the distance of the stream from the project.

b. Describe the characteristics of the project which might create adverse impacts on the stream.

c. Describe measures to be taken to minimize adverse impacts on the stream.

13.	☐	☒	Will the project, absent control measures, result in an increase in the peak discharge rate for stormwater drainage from the project site?

If "yes,"

a. Describe the amount of increase in the peak discharge rate for stormwater drainage.

b. Describe adverse impacts that might result from the increase in peak discharge rate for stormwater drainage.

c. Describe measures to be taken to minimize adverse impacts from the increase in the peak discharge rate for stormwater drainage.

If no, provide documentation supporting this judgment.

14.	☐	☒	Will the project create an increase in traffic on the approach route(s) leading to the project?

If "yes,"

a. Identify the approach route(s) to the project site, and describe them in terms of:

1) design capacities, roadway width and condition;

2) average daily traffic counts (if available from Pennsylvania Department of Transportation);

3) hazardous grades or curves.

	Yes	No	
			b. Describe the expected traffic increase; include number, type, size and weight of vehicles and distribution on approach routes.
			c. Identify and indicate number of residences fronting (50 feet setback or less) on approach route(s) to the project site.
			d. Identify any schools, hospitals, or nursing homes located on the approach route(s) to the project site.
			e. Describe any special routing or timing of traffic to the project site to be provided to minimize conflict with other traffic or to prevent safety hazards. Traffic impacts analyzed for previous questions should be briefly mentioned.
15.	☐	☒	Is the project located within the watershed or aquifer, and within one mile of a public water supply facility dependent on groundwater sources; or upstream, within the watershed, and within three miles of a public water supply facility dependent on surface sources.
			If "yes,"
			a. Identify the public water supply facility, and its supply sources; locate both on a topographic map; and indicate their distances from the project.
			b. Briefly describe the public water supply facility, including capacity and population served.
			c. Describe measures to be taken to protect the public water supply facility from any potential harm.
16.	☐	☒	Is the project located in a landslide, sinkhole, or mine subsidence prone area?
			If "yes," provide the following:
			a. Identify the geologic hazard and the location of the project.
			b. Indicate how the geologic hazard will affect the project.
			c. Describe the engineering and design measures to be taken to minimize the geologic hazard to the project and prevent an increase in danger from the hazard to other property owners in the vicinity.

I.D. Number

FORM D

	Yes	No	
17.	☐	☒	Are wetlands present on the perimeter or adjacent areas?

If yes, provide the following:

a. Do the wetlands serve an important natural biological function, including food chain production; general habitat; and nesting, spawning, rearing and resting sites for aquatic or land species?

b. Are the wetlands set aside for study of the aquatic environment or as sanctuaries or refuges?

c. Would alteration or destruction of the wetlands detrimentally affect natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, natural water filtration process, current patterns or other environmental characteristics?

d. Are the wetlands significant in shielding other areas from wave action, erosion, or storm damage?

e. Do the wetlands serve as valuable storage areas for storm and flood waters?

f. Are the wetlands prime natural recharge areas (that is, locations where surface and groundwater are directly interconnected?)

C. If the applicant determines that the proposed operation may cause environmental harm, provide the Department with a written explanation of how it plans to mitigate the potential harm.

N/A

Part Two: Economic and Social Considerations

For residual waste impoundments and landfills, complete this section. For other facilities, do not complete this section unless requested by the Department.

The applicant shall describe, in writing, the social and economic benefits of the project to the public. The report shall include the following:

N/A - ADMINISTRATIVE REQUIREMENT NOT SUBSTANTIVE ASPECT OF ARAR

a) tax revenue
b) public and private infrastructure
c) compatibility with regional and local economic goals
d) emergency management capabilities
e) loss of resources
f) social service demands
g) other demographic characteristics
h) need for the facility
i) consistency with municipal, county, or regional solid waste plans approved by the Department

APPENDIX 12A
FLOODPLAIN MAP

500-Year Flood Boundary ——— ZONE B

100-Year Flood Boundary ———

Zone Designations* With Date of Identification e.g., 12/2/74 — ZONE A# DATE / ZONE A# DATE

100-Year Flood Boundary ———

500-Year Flood Boundary ——— ZONE B

Base Flood Elevation Line With Elevation In Feet** ——— 513 ———

Base Flood Elevation in Feet Where Uniform Within Zone** (EL 987)

Elevation Reference Mark RM7×

River Mile ●M1.5

**Referenced to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
AO	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

APPROXIMATE SCALE

1000 0 1000 FEET

NATIONAL FLOOD INSURANCE PROGRAM

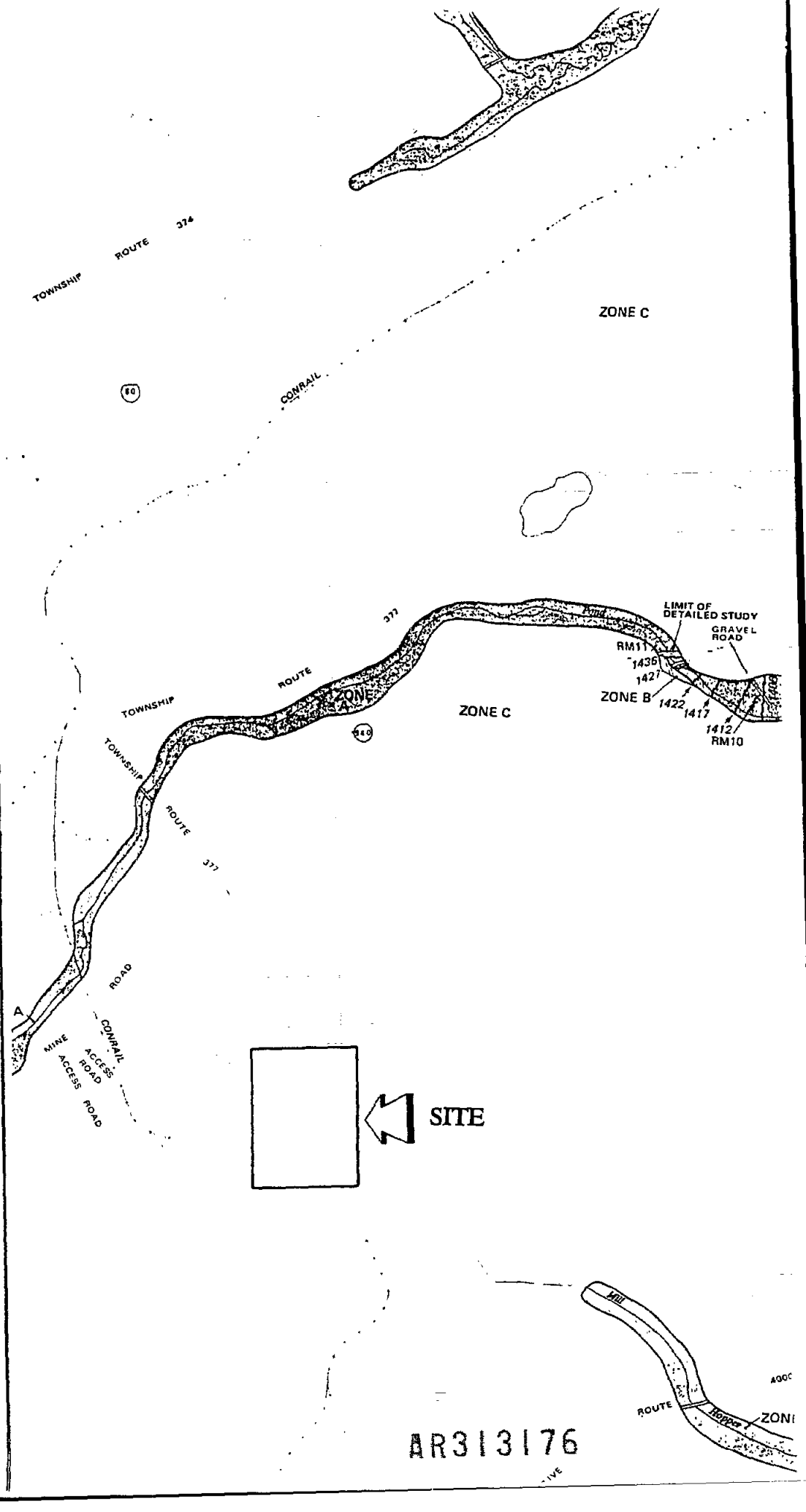
FIRM
FLOOD INSURANCE RATE MAP

TOWNSHIP OF
FOSTER, PENNSYLVANIA
LUZERNE COUNTY

PANEL 15 OF 25
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
421828 0015 A

EFFECTIVE DATE:
APRIL 1, 1981



AR313176

APPENDIX 12B
PROXIMITY OF PRIVATE WELL AT
RESIDENCE WEST OF SHALE PIT

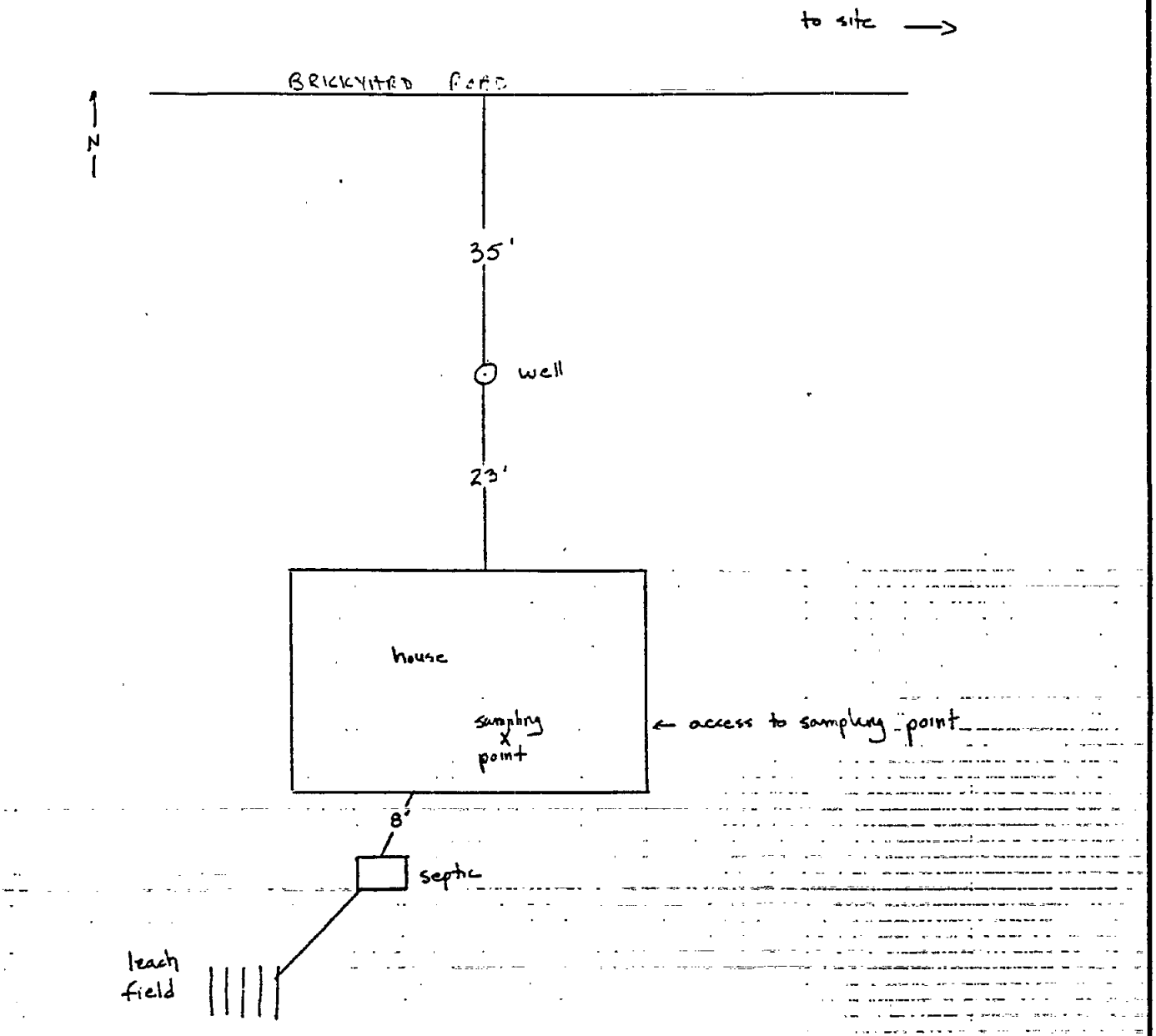
BY JB DATE 6-29-88
CHK'D ____ DATE ____

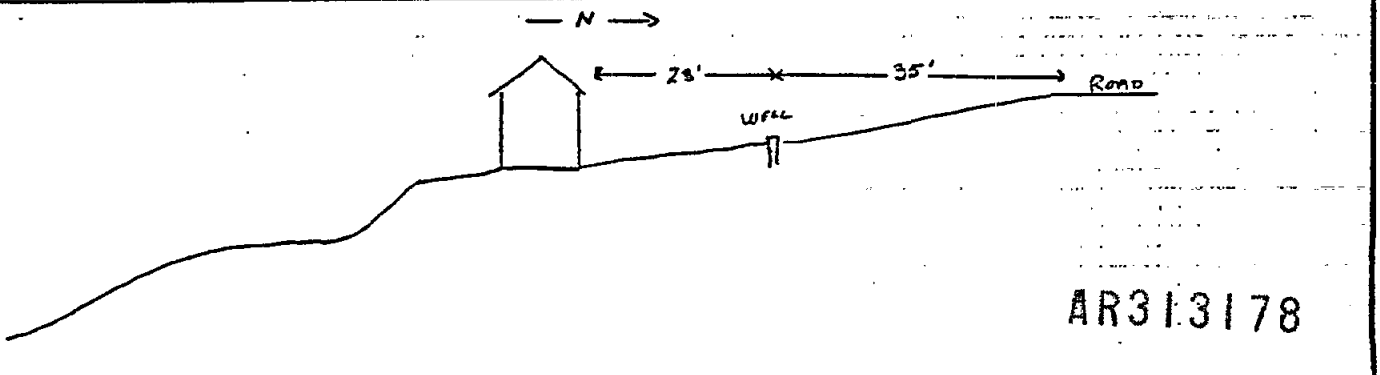
FRED C. HART ASSOCIATES, INC.

SHEET 1 OF 4 PAGE

SUBJECT Initial Residential Well Sampling / C&D Site JOB NO. 0102318 0000903

DRASHER





AR313178

APPENDIX 13
COST ESTIMATES FOR REMEDIAL ALTERNATIVE VI
(SHALE PIT AND NORTHEAST AREAS)

APPENDIX 13
TABLE A

COST ESTIMATE
REMEDIAL ALTERNATIVE VI
ON-SITE CONTAINMENT CELL

SHALE PIT AREA

Item Description	Unit	Unit Cost	Quantity	Total Cost	Reference
CAPITAL COSTS					
I. Common Actions					
Removal/Stabilization of Pond Sediments	l.s.	190,000.00	1	190,000	Table G-1*
Removal of Sewer System Sediment	l.f.	12.00	850	10,200	(1)
Building Decontamination	l.s.	165,600.00	1	165,600	Table G-2*
Removal of Casing and Wire	ton	72.00	1,200	86,400	(2)
		Subtotal, Common Actions		= $452,200	
II. On-site Containment Cell					
Liner Construction					
Isolation Layer	c.y.	17.20	8,300	142,760	(3)
Perforated Pipes	l.f.	6.77	950	6,430	(4)
Six Inch Subbase	c.y.	17.20	985	16,940	(5)
Side Slope Fill	c.y.	17.20	5,900	101,480	(6)
Secondary Liner	s.f.	0.70	53,100	37,170	(7)
Leachate Detection Zone					
Soil	c.y.	17.20	1,967	33,830	(8)
Perforated Piping	l.f.	6.77	950	6,430	(9)
Manhole	ea.	2,000.00	1	2,000	(10)
Primary Liner	s.f.	0.55	53,100	29,205	(11)
Leachate Collection Zone					
Soil	s.f.	17.20	2,950	50,740	(12)
Perforated Piping	c.y.	7.80	950	7,400	(9)
Manhole	ea.	2,000.00	1	2,000	(13)
		Subtotal, On-site Containment Cell Liner		= $487,765	
III. Stabilization of Soil and Ash					
Full Scale Trial Operation	l.s.	50,000.00	1	50,000	(14)
Stabilization	ton	51.00	48,640	2,480,640	(15)
		Subtotal, Soil and Ash Stabilization		= $2,530,640	
IV. On-site Containment Cell					
Cover Construction					
Intermediate Cover (12")	c.y.	10.67	1,967	20,990	(16)
Geotextile layer	s.f.	0.18	53,100	19,120	(17)
60 mil HDPE	s.f.	0.55	53,100	29,200	(18)
Drainage Net	s.f.	0.31	53,100	16,460	(19)
Geotextile layer	s.f.	0.18	53,100	19,120	(17)
Soil (18")	c.y.	10.67	2,950	31,480	(20)
Topsoil (6")	c.y.	18.13	983	17,830	(21)
		Total, On-site Containment Cell Cover		= $154,200	

APPENDIX 13
TABLE A

COST ESTIMATE
REMEDIAL ALTERNATIVE VI
ON-SITE CONTAINMENT CELL

SHALE PIT AREA

Item Description	Unit	Unit Cost	Quantity	Total Cost	Reference
CAPITAL COSTS (continued)					
V. Storm Water and Erosion Control Channels					
Rip Rap Lined	l.f.	17.94	1,750	31,400	(22)
Grass Lined	l.f.	11.94	1,300	15,520	(22)
			Channel Subtotal =	$46,920	
VI. Additional Fence	l.f.	13.00	2,930	38,090	(23)
VII. Groundwater Monitoring Well	l.s.	15,000.00	1	15,000	Table G-4*
VIII. Post-Excavation Sampling and Air Monitoring Program	l.s.	120,000.00	1	120,000	(24)
IX. Asphalt Repaving	s.y	7.50	4,500	33,750	(25)
			Subtotal (Capital Cost) =	$3,801,635	
			Mobilization, Engineering and Contingency (50%) =	$1,900,815	
			Total Capital Cost =	$5,702,450	
ANNUAL COST					
I. Site Maintenance	month	1,150.00	12	13,800	(26)
II. Cell Maintenance	l.s.	3,200.00	1	3,200	(27)
III. Site Inspections	each	3,000.00	2	6,000	
IV. Fence Repair	l.f.	13.00	430	5,590	(28)
IV. Groundwater Monitoring	l.s.	6,230.00	1	6,230	Table G-5*
			Subtotal (Annual Cost) =	34,820	
			Present Worth (30 yrs., 10%, PWF=9.43) =	328,350	
			Contingency (25%) =	82,090	
			Total Present Worth (Annual Cost) =	$410,440	
TOTAL PRESENT WORTH OF ALL COSTS			=	$6,112,890	

APPENDIX 13

TABLE A

COST ESTIMATE
REMEDIAL ALTERNATIVE VI
ON-SITE CONTAINMENT CELL

SHALE PIT AREA

Notes:

* Tables listed refer to tables in Appendix G of FS.

(1) Based on recent similar industrial sewer cleaning project cost, New Jersey and Pennsylvania area. Cost for stabilization is included with cost of pond sediment stabilization, Table G-1.

(2) Based on the following:

a. Transportation and disposal facility price quote for non-hazardous waste transportation ($14/ton) and disposal ($58/ton) in Argyl, PA.

b. Total of 600 cubic yards (Table 4-3) and assumed density of 2.0 tons per cubic yard.

(3) This represents the cost of raising the elevation of the subbase from elevation 1642 (i.e., the bottom of the shale pit) to elevation 1650, as discussed in Section 3.1.16.1 (Ground Water Isolation Distance Requirements).

Quantity:
The quantity of 8,300 cubic yards was determined during the preparation of the FS. (See FS Appendix D, Capacity Analysis, page 3 of 16: cumulative volume from elevation 1642 to 1650.)

Unit Cost:
The unit cost for this item of $17.20 was taken from the bid submitted by Foster Wheeler Enviresponse, Inc. and selected by the NJDEPE for the remediation of the Combe Fill South Landfill. This bid item was for drainage layer material (sand) with a permeability not less than 1.0×10^{-2} cm/sec.

(4) Perforated pipes were included in the design of the ground water isolation layer described in Section 3.1.16.1 (Ground Water Isolation Distance Requirements). Although not required to comply with the requirement for a minimum isolation distance between ground water and the top of the subbase, a drainage system of perforated pipes was included in the design of the shale pit containment cell.

Quantity:
The quantity is based on the perforated pipe system layout (100' maximum spacing) presented in Appendix 13A.

Cost:
The unit cost for this item was taken from the bid submitted by Foster Wheeler Enviresponse, Inc. and selected by the NJDEPE for the remediation of the Combe Fill South Landfill. This bid item was for four inch diameter perforated PVC pipe.

Notes (continued):

(5) This represents the cost of an additional six inch subbase layer of permeable soil. This is in addition to the ground water isolation layer described above.
Quantity:
The dimensions of the on-site containment cell in the shale pit area are: approximately 300 feet long (east-west) and approximately 177 feet wide (north-south). The area to be lined, then, is 53,100 square feet. See Appendix 13A for additional information. The volume of the 6" subbase is 985 cubic yards, or 26,550 cubic feet (53,100 s.f. x 0.6 ft.).
Unit Cost:
See unit cost note No.3.

(6) This represents the cost of adding fill to the existing shale pit side slopes (north and south boundaries) to create a 3 horizontal to 1 vertical slope suitable for liner construction.
Quantity:
See Appendix 13A for quantity of fill to be placed on cell side walls in shale pit area.
Cost:
See unit cost note No.3.

(7) This represents the cost of a composite HDPE and bentonite secondary liner.
Quantity:
The area to be lined is 53,100 square feet. See note No. 5, above.
Cost:
The cost is a price quote of $0.70 for materials and installation from Gundle Lining Systems, Inc. March, 1993.

(8) This represents the costs for the one foot thick permeable (1.0×10^{-2} cm/sec) soil drainage layer in the leachate detection zone.
Quantity:
The quantity is equal to the surface area (i.e., 53,100 square feet) of the shale pit cell (see note No. 5, above) and a one foot depth: 53,100 cubic feet, or 1,967 cubic yards.
Cost:
See unit cost note No.3.

(9) This represents the cost of the 4" diameter perforated piping required for the leachate detection zone.
Quantity:
The quantity is based on the perforated piping system layout presented in Appendix 13A (maximum 100' spacing).
Unit Cost:
See not No. 4, above.

Notes (continued):

(10) This represents the cost of a manhole sump to be connected to the leachate detection zone piping system.
Quantity:
One manhole sump would be used to monitor the potential presence of leachate in the leachate detection zone.
Unit Cost:
Means Construction Cost Guide. Precast, 5' I.D., 8' deep. 027-152-1170.

(11) This represents the cost of the 60 mil HDPE primary liner.
Quantity:
The area to be lined is 53,100 square feet. See note No. 5, above.
Cost:
The cost is price quote from NSC liner for 10 ounce per s.y. geotextile ($0.12/s.f.) plus installation ($0.06/s.f.).

(12) This represents the cost of the 1.5' thick permeable (1.0×10^{-2} cm/sec) soil drainage layer included in the leachate collection zone. This layer also serves as the protective soil cover for the liner system.
Quantity:
The quantity is equal to the surface are (53,100 square feet) of the shale pit cell (see note No. 5, above) and a 1.5' depth: 79,650 cubic feet, or 2,950 cubic yards.
Unit Cost:
See unit cost note No. 3, above.

(13) This represents the cost of a manhole sump to be connected to the leachate collection zone piping system.
Quantity:
One manhole sump would be used to collect leachate from the leachate collection zone. Leachate collection, treatment and disposal is discussed in Section 3.1.17.
Unit Cost:
Means Construction Cost Guide. Precast, 5' I.D., 8' deep. 027-152-1170.

(14) Approximate costs, vendor estimates, for labor, testing, material and equipment for three week trial operation.

Notes (continued):

(15) Based on the following:
- a. Cost: Refer to Table G-6 (Appendix G, FS).
- b. Ash Quantity: Total of 165 c.y. (refer to Section 3.1.4.1, Weight/Volume of Waste) and assumed density of 1.84 tons per cubic yard. Total = 160 c.y. x 1.84 tons/c.y. = 294 tons.
- c. Soil Quantity: Total of 26,273 c.y. (refer to Section 3.1.4.1, Weight/Volume of Waste and Appendix 4A) and assumed density of 1.84 tons per cubic yard. Total = 26,273 c.y. x 1.84 tons/c.y. = 48,342 tons.
- d. Total Soil and Ash Quantity : 294 tons (ash) + 48,342 tons (soil) = 48,636 tons.
  = 48,640 tons (approximately)

(16) This represents the cost of the one foot thick intermediate cover component of the final cover to be placed over the stabilized Site material.
Quantity:
The quantity is equal to the product of the surface area of the shale pit cell (53,100 square feet) and the 1.0 foot depth: 53,100 cubic feet, or 1,967 cubic yards.
Unit Cost:
The unit cost for this item was taken from the bid submitted by Foster Wheeler Enviresponse, Inc. and selected by the NJDEPE for the remediation of the Combe Fill South Landfill. This bid item was for off-site embankment material.

(17) Quantity is equal to surface area of on-site containment cell liner; 135,680 s.f. The cost is price quote from NSC liner for 10 ounce per s.y. geotextile ($0.12/s.f.) plus installation ($0.06/s.f.).

(18) Based on price quote from supplier (NSC, Pittsburgh, PA) of $0.55/s.f. for 60 mil high density polyethylene (HDPE) liner, installed: $0.30/s.f. materials and $0.25/s.f. installation. Quantity is equal to area of on-site containment cell cover (53,100 s.f.).

(19) Based on price quote from supplier (NSC, Pittsburgh, PA) of $0.31/s.f. for geonet drainage layer (PN 3000), installed: $0.25/s.f. materials and $0.06/s.f. installation. Quantity is equal to area of on-site containment cell cover (53,100 s.f.).

(20) For cost, see note No. 16, above. Quantity is equal to the product of the surface area of the on-site containment cell (53,100 square feet) and the 1.5 foot depth: 79,650 cubic feet, or 2,950 cubic yards.

(21) Quantity is equal to the product of the surface area of the on-site containment cell (53,100 square feet) and the 0.5 foot depth of topsoil: 26,550 cubic feet, or 983 cubic yards. The unit cost for this item was taken from the bid submitted by Foster Wheeler Enviresponse, Inc. and selected by the NJDEPE for the remediation of the Combe Fill South Landfill. This bid item was for topsoil.

Notes (continued):

(22) Based on the following:

A. Dimensions of channel cross-section:

width = 13.0 ft.
depth at center = 2.5' (slope = 1H:2V)
thickness of rip rap = 0.75'
cross-sectional area of channel to be excavated = 21.12 s.f.
cross-sectional area of rip rap = 5.06 s.f.

B. Costs - Rip Rap Liner

Excavation = 21.12 s.f./l.f. x 1c.y./27c.f. x $12.14/c.y. (Means, 022-250-2035) = $9.50/l.f.
Load/stockpile = 21.12 s.f./l.f. x 1.0 l.f. x 1c.y./27c.f. x ($1.26/c.y. + $1.87/c.y.) (Means, 022-250-9024, 022-266-0310) = $2.44/l.f.
Rip Rap = 5.06 s.f./l.f. x 1.0 l.f. x 1c.y./27c.f. x $13.50/c.y. (see above) = $2.53/l.f. Place rip rap = 16.0s.f./l.f. x $0.18/sf (see above) = $2.88/l.f.
Geotextile = 16.0 s.f./l.f. x $0.18/s.f. (see above) = $2.88/l.f.
Total = $9.50 + $2.44 + $2.53 + $0.59 + $2.88
= $17.94/l.f.

C. Costs - Grass Lined

Excavation = $9.50/l.f. (see above)
Load/stockpile = 2.44/l.f. see above)
Total = $11.94/l.f.

(23) Means Building Construction Cost Data (1989)
(015-304-0100)
Chain link fence, 6' high: $11.85 per linear foot
Adjusted for inflation: $11.85 x 1.1 = $13.00/l.f. (approximately)

(24) Based on the following costs:

$65,000	Air monitoring program for three months until: (1) off-site and on-site soil consolidation is completed; and (2) first layer (12" intermediate cover) has been installed.
25,000	X-ray florescence field sampler for metals (post-excavation sampling).
10,000	Off-site analytical costs for post-excavation confirmation samples (to confirm field results).
20,000	Labor costs for air monitoring and post-excavation sampling.
120,000	Total costs for air monitoring and post-excavation sampling.

Notes (continued):

(25) Based on the following:

a. Areas to be paved:

Weigh Station Road = 1,292 sq.ft.
Employee Parking Area = 4,857 sq.ft.
Main Facility Parking Area = 34,356 sq.ft.
Total = 40,505 sq.ft
= 4,500 sq.yds.

b. Cost is from Means Construction Cost Data for Philadelphia, three inch asphalt pavement. Present unit costs of $7.50/sq.yd. updated from July 1988 ($6.30 per square yard) using Engineering News Record Construction Cost Index from July, 1988 (5981.27) to November, 1991 (7110.37).

(26) Based on average month charges for maintenance of storm water and erosion control system at Site, period from 1/90 to 1/91 ($900/month) and 5/90 through 5/91 ($140/month). Site security and associated expenses would not be needed.

(27) Based upon the following costs reported in Section 2.1.3.2 of Compendium of Costs for Remedial Technologies at Hazardous Waste Sites; EPA/600/2-87/087; October 1987, adjusted for inflation:

Mowing/revegatation:	$960/year/acre x 2 acres	= 1,920
Erosion control:	$320/year/acre x 2 acres	= 640
Repairs due to shrinkage, swelling or freeze/thaw damage:	$320/year/acre x 2 acres	= 640
	Total	= $3,200

(23) Based on a ten year life for 4,230 l.f. of new (2,930 l.f.) and existing (1,300 l.f.) perimeter fence. Assumes annual repair of ten percent of total length, i.e., 423 l.f. per year (approximately 430 l.f.).

APPENDIX 13
TABLE B

COST ESTIMATE
REMEDIAL ALTERNATIVE VI
ON-SITE CONTAINMENT CELL

NORTHEAST AREA

Item Description	Unit	Unit Cost	Quantity	Total Cost	Reference
CAPITAL COSTS					
I. Common Actions					
Removal/Stabilization of Pond Sediments	l.s.	190,000.00	1	190,000	Table G-1*
Removal of Sewer System Sediment	l.f.	12.00	850	10,200	(1)
Building Decontamination	l.s.	165,600.00	1	165,600	Table G-2*
Removal of Casing and Wire	ton	72.00	1,200	86,400	(2)
		Subtotal, Common Actions	=	$452,200	
II. On-site Containment Cell					
Liner Construction					
Soil Excavation	c.y.	12.46	15,000	186,900	(3)
Rock Excavation	l.f.	20.30	27,225	552,670	(4)
Six Inch Subbase	c.y.	17.20	2,270	39,040	(5)
Secondary Liner	s.f.	0.70	122,500	42,875	(6)
Leachate Detection Zone					
Soil	c.y.	17.20	4,540	78,090	(7)
Perforated Piping	l.f.	6.77	1,900	12,860	(8)
Manhole	ea.	2,000.00	1	2,000	(9)
Primary Liner	s.f.	0.55	122,500	67,375	(10)
Leachate Collection Zone					
Soil	s.f.	17.20	6,810	117,130	(11)
Perforated Piping	c.y.	7.80	1,900	14,800	(8)
Manhole	ea.	2,000.00	1	2,000	(12)
		Subtotal, On-site Containment Cell Liner	=	$1,115,740	
III. Stabilization of Soil and Ash					
Full Scale Trial Operation	l.s.	50,000.00	1	50,000	(13)
Stabilization	ton	51.00	48,640	2,480,640	(14)
		Subtotal, Soil and Ash Stabilization	=	$2,530,640	
IV. On-site Containment Cell					
Cover Construction					
Intermediate Cover (12")	c.y.	10.67	4,540	48,440	(15)
Geotextile layer	s.f.	0.18	122,500	22,050	(16)
60 mil HDPE	s.f.	0.55	122,500	67,375	(17)
Drainage Net	s.f.	0.31	122,500	37,980	(18)
Geotextile layer	s.f.	0.18	122,500	22,050	(16)
Soil (18")	c.y.	10.67	6,805	72,610	(19)
Topsoil (6")	c.y.	18.13	2,270	41,155	(20)
		Total, On-site Containment Cell Cover	=	$311,660	

TABLE B

COST ESTIMATE
REMEDIAL ALTERNATIVE VI
ON-SITE CONTAINMENT CELL

NORTHEAST AREA

Item Description	Unit	Unit Cost	Quantity	Total Cost	Reference
CAPITAL COSTS (continued)					
V. Storm Water and Erosion Control Channels					
Rip Rap Lined	l.f.	17.94	1,750	31,400	(22)
Grass Lined	l.f.	11.94	1,300	15,520	(22)
			Channel Subtotal =	$46,920	
VI. Additional Fence	l.f.	13.00	2,930	38,090	(23)
VII. Groundwater Monitoring Well	l.s.	15,000.00	1	15,000	Table G-4*
VIII. Post-Excavation Sampling and Air Monitoring Program	l.s.	120,000.00	1	120,000	(24)
IX. Asphalt Repaving	s.y	7.50	4,500	33,750	(25)
			Subtotal (Capital Cost) =	$3,801,635	
Mobilization, Engineering and Contingency (50%) =				$1,900,815	
			Total Capital Cost =	$5,702,450	
ANNUAL COST					
I. Site Maintenance	month	1,150.00	12	13,800	(26)
II. Cell Maintenance	l.s.	4,800.00	1	4,800	(27)
III. Site Inspections	each	3,000.00	2	6,000	
IV. Fence Repair	l.f.	13.00	430	5,590	(28)
IV. Groundwater Monitoring	l.s.	6,230.00	1	6,230	Table G-5*
			Subtotal (Annual Cost) =	35,880	
			Present Worth (30 yrs., 10%, PWF=9.43) =	338,350	
			Contingency (25%) =	84,590	
			Total Present Worth (Annual Cost) =	$429,300	
TOTAL PRESENT WORTH OF ALL COSTS			=	$7,425,300	

APPENDIX 13

TABLE b

COST ESTIMATE
REMEDIAL ALTERNATIVE VI
ON-SITE CONTAINMENT CELL

NORTHEAST AREA

Notes:

* Tables listed refer to tables in Appendix G of FS.

(1) Based on recent similar industrial sewer cleaning project cost, New Jersey and Pennsylvania area. Cost for stabilization is included with cost of pond sediment stabilization, Table G-1.

(2) Based on the following:

a. Transportation and disposal facility price quote for non-hazardous waste transportation ($14/ton) and disposal ($58/ton) in Argyl, PA.

b. Total of 600 cubic yards (Table 4-3) and assumed density of 2.0 tons per cubic yard.

(3) Quantity is for excavation of four feet of soil for the base area of approximately 122,500 square feet (see Appendix 13B). Cost is from Means, Common Earth Excavation, hydraulic backhoe, 3/4 cu. yd. bucket (022-250-2035). Updated for inflation to $12.46 per cubic yard.

(4) Quantity is for excavation of rock to a 5 % maximum bottom slope. See Appendix 13B for calculations. Cost is from Means, updated for inflation:
Drilling and Blasting (over 1,500 cu. yds.) (022-234-0100)
Cost = $6.26 per cubic yard
Excavation, blasted rock, 3/4 cu. yd. bucket (022-250-3010)
Cost = $14.04 per cubic yard
Total unit cost = $6.26 + $14.04 = $20.30 per cubic yard

(5) This represents the cost of a six inch subbase layer of permeable soil.
Quantity:
The surface area of the on-site containment cell in the northeast area is approximately 122,500 cubic yards. See Appendix 13B for additional information. The volume of the 6" subbase is 2,270 cubic yards.
Unit Cost:
The unit cost for this item of $17.20 was taken from the bid submitted by Foster Wheeler Enviresponse, Inc. and selected by the NJDEPE for the remediation of the Combe Fill South Landfill. This bid item was for drainage layer material (sand) with a permeability not less than 1.0×10^{-2} cm/sec.

Notes (continued):

(6) This represents the cost of a composite HDPE and bentonite secondary liner.
Quantity:
The area to be lined is 122,500 square feet. See note No. 5, above.
Cost:
The cost is a price quote of $0.70 for materials and installation from Gundle Lining Systems, Inc. March, 1993.

(7) This represents the costs for the one foot thick permeable (1.0×10^{-2} cm/sec) soil drainage layer in the leachate detection zone.
Quantity:
The quantity is equal to the surface area (i.e., 122,500 square feet) of the northeast area cell (see note No. 5, above) and a one foot depth: 122,500 cubic feet, or 4,540 cubic yards.
Cost:
See unit cost note No.5.

(8) This represents the cost of the 4" diameter perforated piping required for the leachate detection zone.
Quantity:
The quantity is based on the perforated piping system layout presented in Appendix 13B (maximum 100' spacing).
Unit Cost:
The unit cost for this item was taken from the bid submitted by Foster Wheeler Enviresponse, Inc. and selected by the NJDEPE for the remediation of the Combe Fill South Landfill. This bid item was for four inch diameter perforated PVC pipe.

(9) This represents the cost of a manhole sump to be connected to the leachate detection zone piping system.
Quantity:
One manhole sump would be used to monitor the potential presence of leachate in the leachate detection zone.
Unit Cost:
Means Construction Cost Guide. Precast, 5' I.D., 8' deep. 027-152-1170.

(10) This represents the cost of the 60 mil HDPE primary liner.
Quantity:
The area to be lined is 122,500 square feet. See note No. 5, above.
Cost:
The cost is price quote from NSC liner for 10 ounce per s.y. geotextile ($0.12/s.f.) plus installation ($0.06/s.f.).

APPENDIX 13

TABLE B

COST ESTIMATE
REMEDIAL ALTERNATIVE VI
ON-SITE CONTAINMENT CELL

NORTHEAST AREA

Notes (continued):

(11) This represents the cost of the 1.5' thick permeable (1.0×10^{-2} cm/sec) soil drainage layer included in the leachate collection zone. This layer also serves as the protective soil cover for the liner system.
Quantity:
The quantity is equal to the surface are (122,500 square feet) of the shale pit cell (see note No. 5, above) and a 1.5' depth: 183,750 cubic feet, or 6,810 cubic yards.
Unit Cost:
See unit cost note No. 5, above.

(12) This represents the cost of a manhole sump to be connected to the leachate collection zone piping system.
Quantity:
One manhole sump would be used to collect leachate from the leachate collection zone. Leachate collection, treatment and disposal is discussed in Section 3.1.17.
Unit Cost:
Means Construction Cost Guide. Precast, 5' I.D., 8' deep. 027-152-1170.

(13) Approximate costs, vendor estimates, for labor, testing, material and equipment for three week trial operation.

(14) Based on the following:
a. Cost: Refer to Table G-6 (Appendix G, FS).
b. Ash Quantity: Total of 165 c.y. (refer to Section 3.1.4.1, Weight/Volume of Waste) and assumed density of 1.84 tons per cubic yard. Total = 160 c.y. x 1.84 tons/c.y. = 294 tons.
c. Soil Quantity: Total of 26,273 c.y. (refer to Section 3.1.4.1, Weight/Volume of Waste and Appendix 4A) and assumed density of 1.84 tons per cubic yard. Total = 26,273 c.y. x 1.84 tons/c.y. = 48,342 tons.
d. Total Soil and Ash Quantity : 294 tons (ash) + 48,342 tons (soil) = 48,636 tons.
= 48,640 tons (approximately)

(15) This represents the cost of the one foot thick intermediate cover component of the final cover to be placed over the stabilized Site material.
Quantity:
The quantity is equal to the product of the surface area of the shale pit cell (122,500 square feet) and the 1.0 foot depth: 122,500 cubic feet, or 4,540 cubic yards.
Unit Cost:
The unit cost for this item was taken from the bid submitted by Foster Wheeler Enviresponse, Inc. and selected by the NJDEPE for the remediation of the Combe Fill South Landfill. This bid item was for off-site embankment material.

Notes (continued):

(16) Quantity is equal to surface area of on-site containment cell liner; 122,500 s.f. The cost is price quote from NSC liner for 10 ounce per s.y. geotextile ($0.12/s.f.) plus installation ($0.06/s.f.).

(17) Based on price quote from supplier (NSC, Pittsburgh, PA) of $0.55/s.f. for 60 mil high density polyethylene (HDPE) liner, installed: $0.30/s.f. materials and $0.25/s.f. installation. Quantity is equal to area of on-site containment cell cover (122,500 s.f.).

(18) Based on price quote from supplier (NSC, Pittsburgh, PA) of $0.31/s.f. for geonet drainage layer (PN 3000), installed: $0.25/s.f. materials and $0.06/s.f. installation. Quantity is equal to area of on-site containment cell cover (53,100 s.f.).

(19) For cost, see note No. 15, above. Quantity is equal to the product of the surface area of the on-site containment cell (122,500 square feet) and the 1.5 foot depth: 183,750 cubic feet, or 6,805 cubic yards.

(20) Quantity is equal to the product of the surface area of the on-site containment cell (122,500 square feet) and the 0.5 foot depth of topsoil: 61,250 cubic feet, or 2,270 cubic yards. The unit cost for this item was taken from the bid submitted by Foster Wheeler Enviresponse, Inc. and selected by the NJDEPE for the remediation of the Combe Fill South Landfill. This bid item was for topsoil.

(21) Based on the following:

A. Dimensions of channel cross-section:

width = 13.0 ft.
depth at center = 2.5' (slope = 1H:2V)
thickness of rip rap = 0.75'
cross-sectional area of channel to be excavated = 21.12 s.f.
cross-sectional area of rip rap = 5.06 s.f.

B. Costs - Rip Rap Liner

Excavation = 21.12 s.f./l.f. x 1c.y./27c.f. x $12.14/c.y. (Means, 022-250-2035) = $9.50/l.f.
Load/stockpile = 21.12 s.f./l.f. x 1.0 l.f. x 1c.y./27c.f. x ($1.26/c.y. + $1.87/c.y.) (Means, 022-250-9024, 022-266-0310) = $2.44/l.f.
Rip Rap = 5.06 s.f./l.f. x 1.0 l.f. x 1c.y./27c.f. x $13.50/c.y. (see above) = $2.53/l.f. Place rip rap = 16.0s.f./l.f. x $0.18/sf (see above) = $2.88/l.f.
Geotextile = 16.0 s.f./l.f. x $0.18/s.f. (see above) = $2.88/l.f.
Total = $9.50 + $2.44 + $2.53 + $0.59 + $2.88
= $17.94/l.f.

Notes (continued):

C. Costs - Grass Lined .
Excavation = $9.50/l.f. (see above)
Load/stockpile = 2.44/l.f. see above)
Total = $11.94/l.f.

(22) Means Building Construction Cost Data (1989)
(015-304-0100)
Chain link fence, 6' high: $11.85 per linear foot
Adjusted for inflation: $11.85 x 1.1 = $13.00/l.f. (approximately)

(23) Based on the following costs:

$65,000	Air monitoring program for three months until: (1) off-site and on-site soil consolidation is completed; and (2) first layer (12" intermediate cover) has been installed.
25,000	X-ray florescence field sampler for metals (post-excavation sampling).
10,000	Off-site analytical costs for post-excavation confirmation samples (to confirm field results).
20,000	Labor costs for air monitoring and post-excavation sampling.
120,000	Total costs for air monitoring and post-excavation sampling.

(24) Based on the following:

a. Areas to be paved:
Weigh Station Road = 1,292 sq.ft.
Employee Parking Area = 4,857 sq.ft.
Main Facility Parking Area = 34,356 sq.ft.
Total = 40,505 sq.ft
= 4,500 sq.yds.

b. Cost is from Means Construction Cost Data for Philadelphia, three inch asphalt pavement. Present unit costs of $7.50/sq.yd. updated from July 1988 ($6.30 per square yard) using Engineering News Record Construction Cost Index from July, 1988 (5981.27) to November, 1991 (7110.37).

(25) Based on average month charges for maintenance of storm water and erosion control system at Site, period from 1/90 to 1/91 ($900/month) and 5/90 through 5/91 ($140/month). Site security and associated expenses would not be needed.

Notes (continued):

(26) Based upon the following costs reported in Section 2.1.3.2 of Compendium of Costs for Remedial Technologies at Hazardous Waste Sites; EPA/600/2-87/087; October 1987, adjusted for inflation:

Mowing/revegatation:	$960/year/acre x 3 acres	= 2,880
Erosion control:	$320/year/acre x 2 acres	= 960
Repairs due to shrinkage, swelling or freeze/thaw damage:	$320/year/acre x 2 acres	= 960
	Total	= $4,800

(27) Based on a ten year life for 4,230 l.f. of new (2,930 l.f.) and existing (1,300 l.f.) perimeter fence. Assumes annual repair of ten percent of total length, i.e., 423 l.f. per year (approximately 430 l.f.).

APPENDIX 13A
COST ESTIMATE WORK SHEETS: SHALE PIT AREA CELL

THE FOLLOWING WORK SHEETS DESCRIBE THE SIZING OF THE ON-SITE CONTAINMENT CELL IN THE SHALE PIT AREA. THE SIZE OF THE CELL WAS DESIGNED TO CONTAIN THE APPROXIMATELY 28,400 CUBIC YARDS OF STABILIZED MATERIAL (SEE SECTION 3.1.4.1).

PLAN VIEW - HORIZONTAL DIMENSIONS

THE ATTACHED DRAWING PAGE 2 SHOWS THE BASE OR FOOTPRINT OF THE ON-SITE CONTAINMENT CELL IN THE SHALE PIT AREA. THE 1660 ELEVATION WAS USED AS THE EMBANKMENT ELEVATION ABOVE WHICH THE FINAL COVER SLOPE WOULD BEGIN.

THE LENGTH OF THE CELL AS SHOWN ON THE DRAWING IS APPROXIMATELY 300'. THE WIDTH AT THE 1660 ELEVATION IS APPROXIMATELY 177'.

THE TOTAL SURFACE AREA (TO BE USED FOR LINER + COVER COST ESTIMATES) IS AS FOLLOWS:

$$\text{SURFACE AREA} = 300' \times 177'$$
$$= 53{,}100 \text{ SQ. FT.}$$

CROSS-SECTION - VERTICAL DIMENSIONS + CAPACITY

THE CAPACITY OF THIS DESIGN WAS COMPUTED BY DEVELOPING A NORTH-SOUTH CROSS-SECTION OF THE CELL. THIS CROSS-SECTION LOCATION IS SHOWN ON PAGE 2. THE CROSS SECTION IS SHOWN ON PAGE 3.

THE SHALE PIT SIDE SLOPES ON THE EASTERN EM OF THE AREA WOULD BE EXCAVATED TO MATCH THE DIMENSION OF CROSS-SECTION A-A'.

THE CROSS-SECTION WAS COMPUTED AS FOLLOWS: (SEE CROSS-SECTION, PAGE 3):

I. CROSS-SECTIONAL AREA FROM LINER TO EMBANKMENT (p. 3):

$$\text{AREA} = \left(\frac{10' + 12.5'}{2}\right) \times \left(\frac{177' + 110'}{2}\right)$$
$$= 11.25' \times 143.5'$$
$$= 1{,}614 \text{ SQ. FT.}$$

$$\text{VOLUME OF THIS SECTION} = 1614 \text{ SQ FT} \times 300'$$
$$= 484{,}200 \text{ CUBIC FEET}$$
$$= 17{,}930 \text{ CUBIC YARDS}$$

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Project C+D RECYCLING SITE W.O. No. 631.002.03 Sheet 2 of 5
Subject DESIGN NOTES By J. LAINDINK Date 3-22-93
SHALE PIT CONTAINMENT CELL Chkd. by _____ Date _____

N

This area, in addition to foundation of cell, is to be filled to elevation 1650. See Section 3.1.16.1.

Location of perforated pipe system layout. The same layout is used for the following: (1) ground water isolation layer; (2) leachate collection zone; and (3) leachate detection zone.

Berm to be constructed on east end of cell.

Boundary of liner system (including 15' edge to waste)

See page 2 for cross-sectional view.

PLAN VIEW
ON-SITE CONTAINMENT CELL
SHALE PIT LOCATION

Scale: 1" = 100'

AR313196

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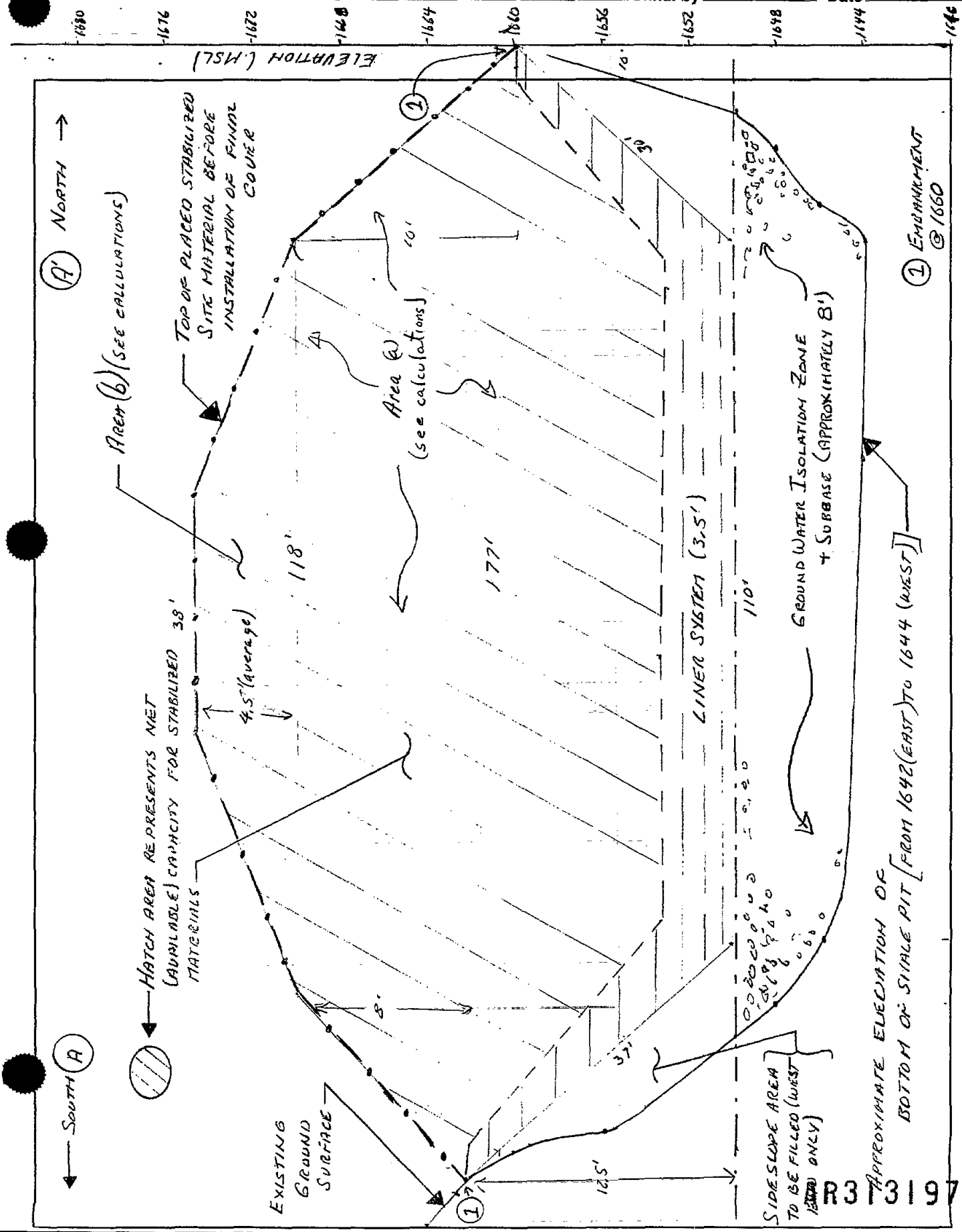
Project C & D Recycling Site W.O. No. 631.002.03 Sheet 3 of 5
Subject Design Notes By John Iannone Date 3-22-93
Shale Pit On-Site Containment Cell Chkd. by ____ Date ____



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(continued from page 1)

CROSS-SECTION - VERTICAL DIMENSION + CAPACITY (continued)

II. CROSS-SECTIONAL AREA (a) (see page 3, area above embankment)

$$\text{AREA} = \left(\frac{8' + 10'}{2}\right) \times \left(\frac{118' + 177'}{2}\right)$$

$$= 9 \times 147.5$$

$$= 1,327.5 \text{ SQ. FT.}$$

CROSS-SECTION AREA (b) (see page 3, area under final cover)

$$\text{AREA} = 4.5' \times \left(\frac{118 + 38}{2}\right)$$

$$= 4.5' \times 78'$$

$$= 351 \text{ SQ. FT.}$$

TOTAL CROSS-SECTIONAL AREA (a) AND (b) = 1327.5 SQ FT + 351 SQ FT

= 1,678.5 SQ FT

VOLUME OF THIS SECTION = 1678.5 SQ. FT. × 300 FT

= 503,550 CU. FT.

= 18,650 CU. YD.

VOLUME OF I. AND II. (TOTAL SHALE PIT CELL CAPACITY) =

17,930 CU. YDS

18,650 CU. YDS

TOTAL VOLUME = 36,580 CU. YDS

NET (AVAILABLE) CAPACITY

A PART OF THIS CAPACITY WILL BE USED FOR INSTALLATION OF THE 3.5' THICK LINER SYSTEM. THE VOLUME OCCUPIED BY THIS LINER SYSTEM SHOULD BE SUBTRACTED FROM THE TOTAL VOLUME LISTED ABOVE (36,580 CU. YDS.). THE REMAINING VOLUME IS THE NET CAPACITY OF THE CELL, I.E. THE VOLUME OR CAPACITY AVAILABLE FOR PLACEMENT OF STABILIZED MATERIAL.

LINER VOLUME = 3.5' × 53,100 SQ FT (see p. 1) = 185,850 CU. FT.

= 6,880 CU. YDS.

NET AVAILABLE CAPACITY = 36,580 CU. YDS − 6,880 CU YDS = 29,697 CU YDS

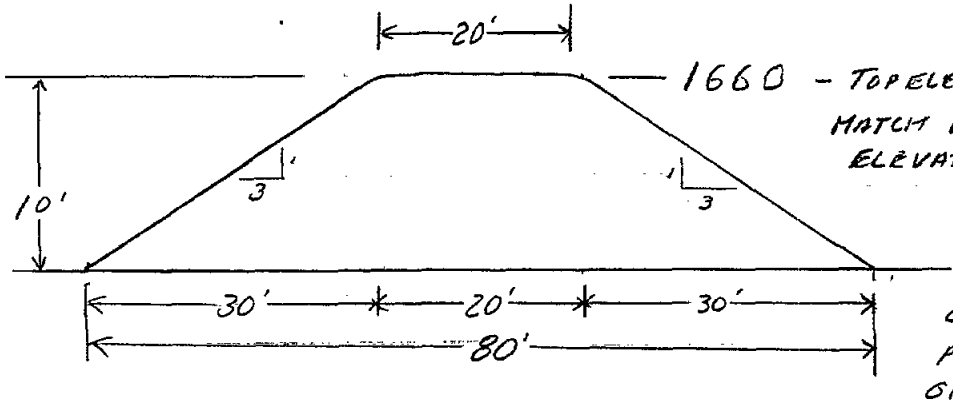
EXCESS CAPACITY = 29,697 CU YDS − 28,400① CU YDS = 1,297 CU YDS

① STABILIZED SITE MATERIAL; SEE SECTION 3.1.4.1.

Project C+D RECYCLING SITE W.O. No. 631.002.03 Sheet 5 of 5
Subject DESIGN NOTES By J. IANNONE Date 3-23-93
SHALE PIT CONTAINMENT CELL Chkd. by _____ Date _____

BERM - EAST END

A BERM WOULD BE CONSTRUCTED ON THE EAST END OF THE SHALE PIT CELL TO COMPLETE THE EMBANKMENT FORMED BY THE 1660 ELEVATION. A CROSS-SECTION (EAST-WEST) OF THE BERM WOULD BE AS FOLLOWS.



1660 - TOP ELEVATION OF BERM TO MATCH 1660 EMBANKMENT ELEVATION.

1650 - ELEVATION OF TOP OF SUBBASE PLACED TO MEET GROUND WATER ISOLATION DIST. REQ'TS

$$\text{CROSS-SECTIONAL AREA} = \left(\frac{80' + 20'}{2}\right) \times 10'$$

$$= 500 \text{ SQ. FT.}$$

$$\text{VOLUME} = 500 \text{ SQ FT.} \times 200 \text{ LINEAR FEET}^*$$

$$= 100{,}000 \text{ C.F.}$$

$$= 3{,}700 \text{ CU. YDS}$$

* SEE PLAN VIEW, PAGE 2, EAST END

APPENDIX 13B
COST ESTIMATE WORK SHEETS: NORTHEAST AREA CELL

Project C & D Recycling Site W.O. No. 631.002.03 Sheet 1 of 8
Subject Design Notes By Jumin Iannoine Date 3-23-93
Northeast Area Containment Cell Chkd. by _____ Date _____

The following work sheets describe the sizing of the on-site containment cell in the Northeast area. The size of the cell was designed to contain the approximately 28 400 cubic yards of stabilized material (see Section 3.1.4.1).

Components to Northeast Area Capacity

There are 3 components to the overall capacity of the Northeas area cell:

1. The volume of rock excavated to provide a stable slope.
2. The volume of soil excavated to expose bedrock
3. The volume of stabilized material that can be placed at a slope (i.e., mounded) to an elevation higher than that of the existing grade (i.e soil surface).

Cell Sizing

The cell was sized by first approximating the surface area that would be needed by the base or footprint of the cell. The volume of each of the 3 components to the overall capacity of the NE cell, listed above, was then calculated based on this surface area.

Base (or Footprint) Surface Area Approximation

A total of approximately 30,000 cu. yds of stabilized materials be placed. An overall depth of 8' was used to determine the surface area needed. This dimension (depth) was selected based on the limited mounding that might be available due to the existing slope of the NE Area.

$$\text{Surface Area} = \frac{30{,}000 \text{ cu yds} \times 27 \text{ cf/cy}}{8 \text{ feet (depth)}}$$

$$= 101{,}250 \text{ sq. ft.}$$

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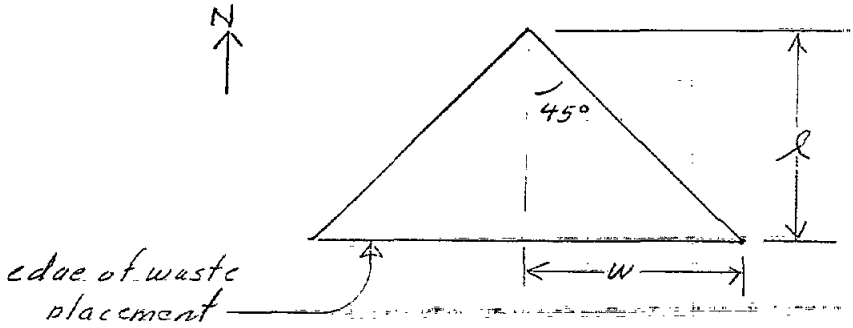
Project C+D Recycling Site W.O. No. 631.002.03 Sheet 2 of 8

Subject Design Notes By J. Iannone Date 3-23-93

Northeast Area Containment Cell Chkd. by _____ Date _____

Base (or Footprint) Dimensions

The shape of the NE area base is triangular, due to the slope + grade in this area (see Appendix G, FS Geotechnical Report). The dimensions of a triangular base (an isosceles triangle - two equal sides) were calculated as follows:



$$\text{Surface Area} = \left[\left(\tfrac{1}{2}\ell\right) \times w\right] \times 2$$

$$\ell = \tan 45° (w)$$

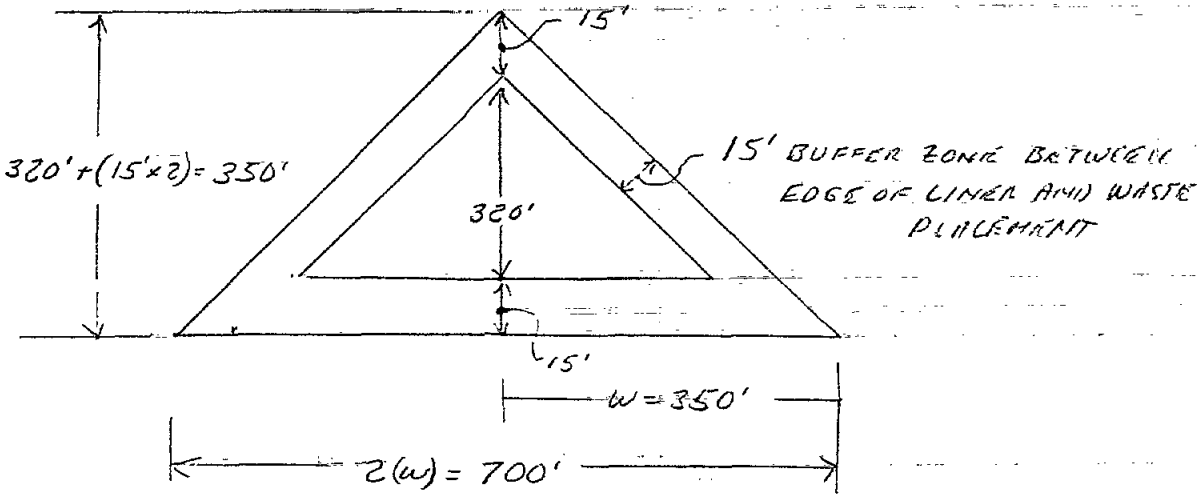
$$\ell = w$$

$$\text{Surface Area} = \ell^2$$

$$\ell = \sqrt{101,250 \text{ sf}}$$

$$= 320 \text{ feet}$$

This dimension must be increased to address the regulatory requirement to extend the liner 15' beyond the edge of waste placement. The resulting dimensions are as follows:



Final Base (or Footprint) Surface Area

The surface area of the base including the 15' liner buffer was calculated as follows:

Surface Area = $[(1/2 \times 350') \times 350'] \times 2$

= 122,500 sq. ft.

Quantity of Soil to be Excavated

Approximately 4' of soil would be excavated to expose bedrock. This would provide the most stable surface for the cell and would provide the greatest structural support.

From Figure 3-11 in the RI it was determined that there is approximately 4' (or less) of soil in this area.

The location of the NE cell (see plan view, page 4) was moved slightly to the south + west. This movement is not critical to the design or these calculations (the slope in this area is relatively constant). The location shown on page 4 however maximizes the distance to the property line + provides an added buffer distance.

Quantity of Soil to be Excavated =

= 4' x 122,500 sf

= 490,000 cu. ft.

= 18,150 cu. yds.

Project: C&D Recycling Site W.O. No.: 631.002.03 Page 4 of 7

Subject: Design Notes By: John Iannone Date: 3-24-93

Location of perforated pipe system layout. The same layout is used for the following: (1) leachate collection zone; and (2) leachate detection zone.

Boundary of liner system (including 15' edge to waste)

PLAN VIEW
ON-SITE CONTAINMENT CELL
NORTHEAST AREA LOCATION

Scale: 1" = 100'

AR313203

QUANTITY OF ROCK TO BE EXCAVATED:

AFTER OVERBURDEN SOIL IS REMOVED ROCK WILL BE EXCAVATED FROM THE NORTHERN (UPGRADE) PORTION OF THE CELL TO PROVIDE A FLATTER, MORE STABLE FOUNDATION.

THE AMOUNT OF ROCK TO BE EXCAVATED WAS CALCULATED AS FOLLOWS:

1. CALCULATE THE VOLUME OF ROCK IN THE BASE AREA ASSUMING THE SLOPE OF THE BASE IS ZERO (FLAT)
2. CALCULATE THE VOLUME OF ROCK THAT WOULD BE LEFT IN PLACE IF THE SLOPE OF THE BASE WAS INCREASED BY AN ACCEPTABLE AMOUNT (i.e., 5%)
3. SUBTRACT (2) FROM (1) TO DETERMINE THE CAPACITY AVAILABLE FOR CELL USE.

THE CALCULATIONS ARE AS FOLLOWS:

1. VOLUME OF FLAT BOTTOM (TOTAL VOLUME OF ROCK TO FLAT BOTTOM):

VOLUME = 1/3 (BASE AREA) x HEIGHT

BASE AREA = 122,500 SQ. FT. (see page 3)

HEIGHT = ELEVATION (3) − ELEVATION AT BASE

= 1722 − 1686

= 36'

VOLUME = 1/3 (122,500) x 36'

= 1,470,000 CU. FT

= 54 440 CU YDS

2. VOLUME OF ROCK TO BE LEFT IN PLACE (ASSUME SLOPE OF BOTTOM OF CELL = 5%)

VOLUME = 1/3 (BASE AREA) x HEIGHT

BASE AREA = 122,500 SF

HEIGHT = ELEVATION (2) − ELEVATION AT BASE

= 1704 − 1686

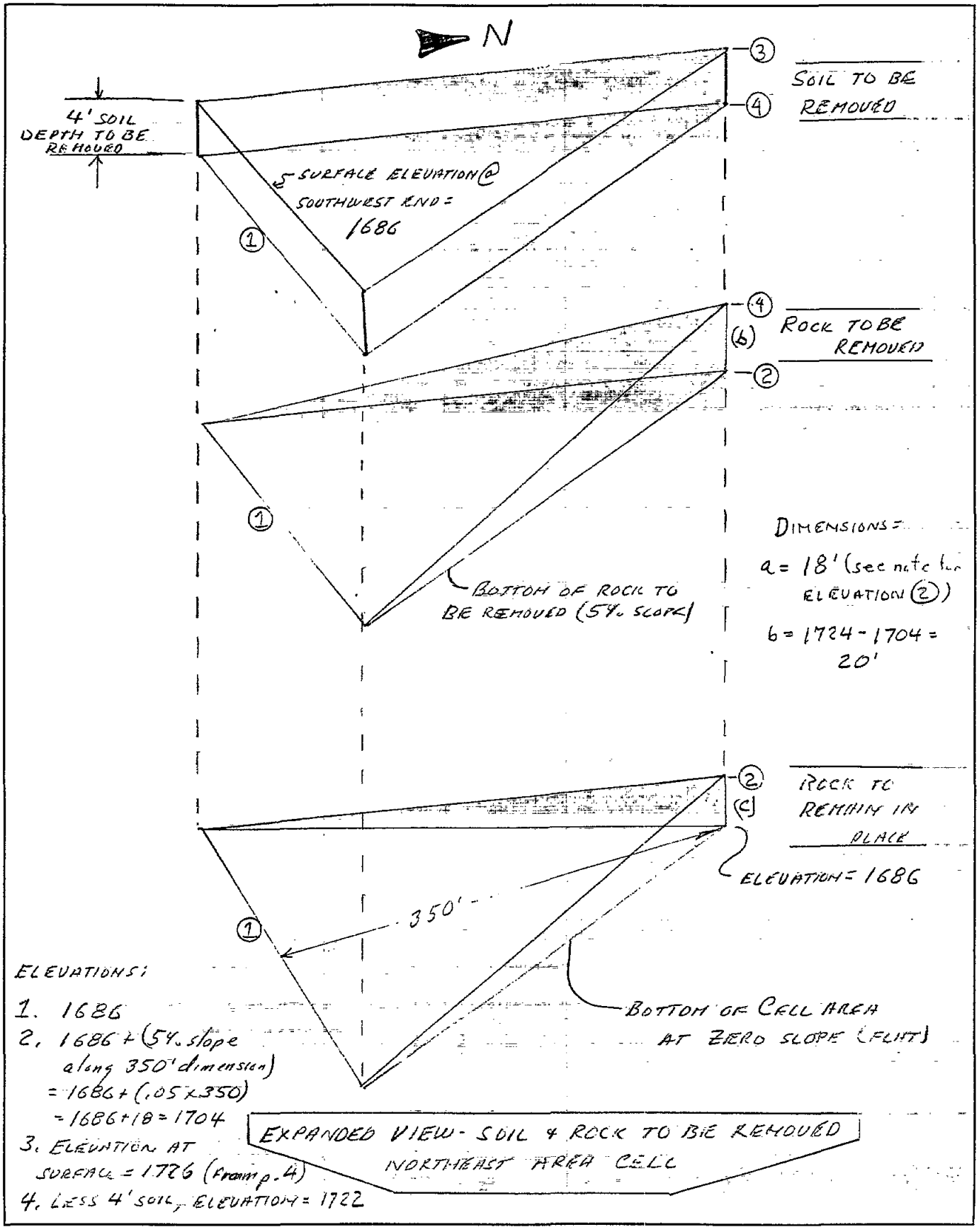
= 18'

VOLUME = 1/3 (122,500) x 18'

= 735,000 CU. FT

= 27,220 CU. YDS

Project C+D Recycling Site W.O. No. 631.002.03 Sheet 6 of 13
Subject Design Notes By Jimmy Tammone Date 3-24-93
Northeast Area Containment Cell Chkd. by _____ Date _____



EXPANDED VIEW - SOIL & ROCK TO BE REMOVED
NORTHEAST AREA CELL

AR313205

QUANTITY OF ROCK TO BE EXCAVATED: (continued)

3. CAPACITY AVAILABLE =

FLAT BOTTOM VOLUME = 54,440 cu yds
- SLOPED BOTTOM VOLUME = - 27,220 cu yds
AVAILABE CAPACITY
FROM ROCK EXCAVATION = 27,220 cu. yds

CAPACITY FROM MOUNDING

THE SOIL AND ROCK EXCAVATION DERIVES THE AVAILABLE CAPACITY OF THE NE CELL AREA ASSUMING WASTE IS PLACED TO MEET EXISTING GRADE. ADDITIONAL CAPACITY CAN BE OBTAINED BY MOUNDING THE WASTE IN THE CELL, ABOVE THE EXISTING GRADE. A CROSS-SECTION (P. 7) OF A TYPICAL CROSS-SECTION WAS DEVELOPED USING THE 33% GRADE IN THE SOUTH + 3% IN THE NORTH THE X-SECTIONAL AREA = 2,260 SQ. FT. THE LENGTH OF THIS X-SECTION AT 1/3 THE LENGTH IS 250'

VOLUME = 2,260 SF x 250'
= 20,930 CY

TOTAL CAPACITY

SOIL = 18,150 CY
ROCK = 27,220 CY
MOUNDING = 20,930 CY
66,300 CY
- 31,800 CY LINER + COVER (3.5+3.5') x 122,500 SF = 31,800 CY
AVAILABLE CAP = 34,500

COMPARISON

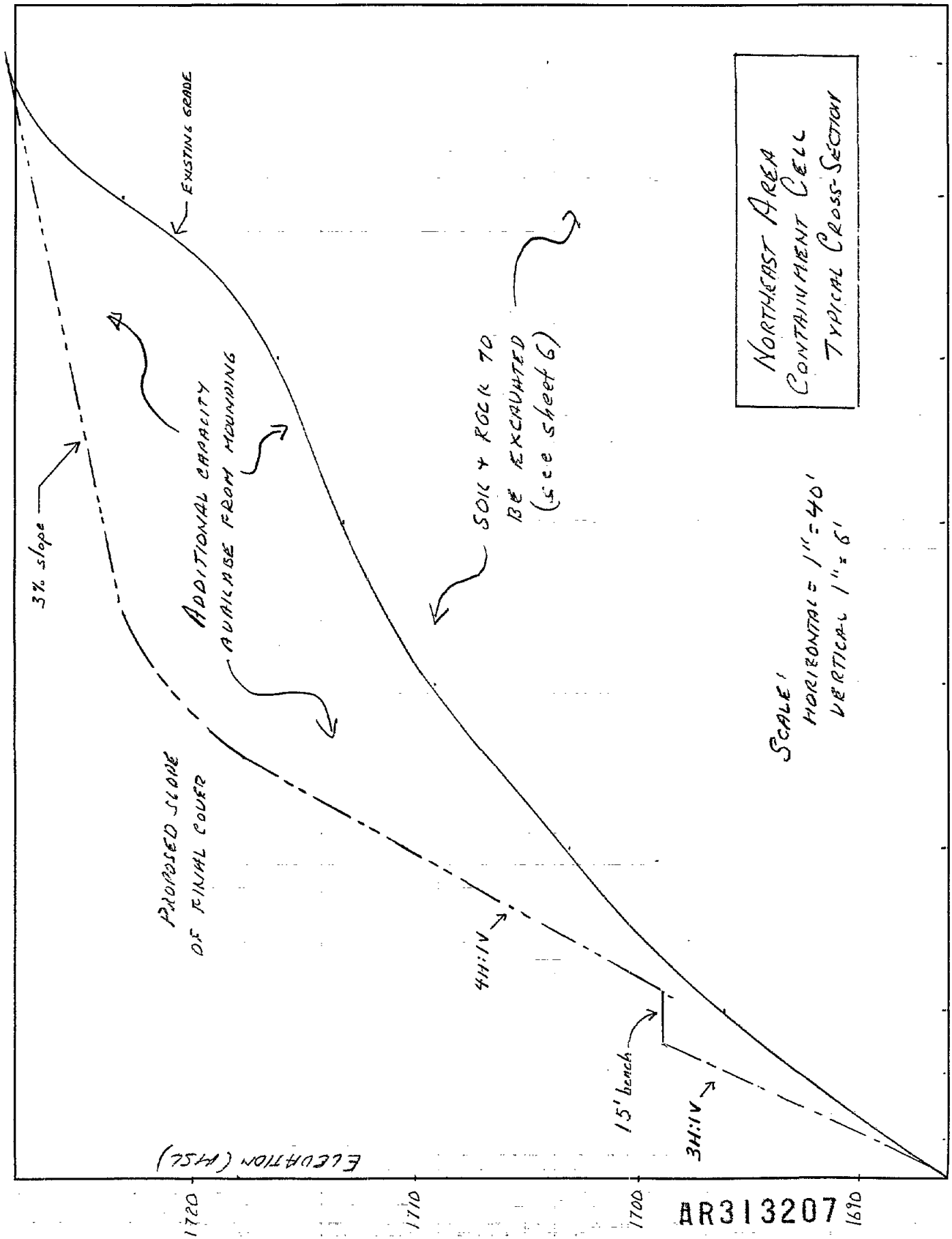
THIS CAPACITY OF 34,500 CY IS 6,100 CY GREATER THAN 28,400 (SEE P. 1)

AR313206

Project C+D RECYCLING SITE W.O. No. 531.002.03 Sheet 8 of 8

Subject DESIGN NOTES By JOHN IANNONE Date 3-24-93

NORTHEAST AREA CONTAINMENT CELL Chkd. by _____ Date _____



1730-

PLATES

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Volume III T - Filecom

REPORT OR DOCUMENT TITLE On Site Containment Cell Technical and Regulatory Compliance Evaluation
DATE OF DOCUMENT 3/29/99
DESCRIPTION OF IMAGERY Plate 1

NUMBER AND TYPE OF IMAGERY ITEM(S) 1 oversized map

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DATE OF DOCUMENT 3/29/93
DESCRIPTION OF IMAGERY Cross Sections A-A and B-B
NUMBER AND TYPE OF IMAGERY ITEM(S) 1 oversized map